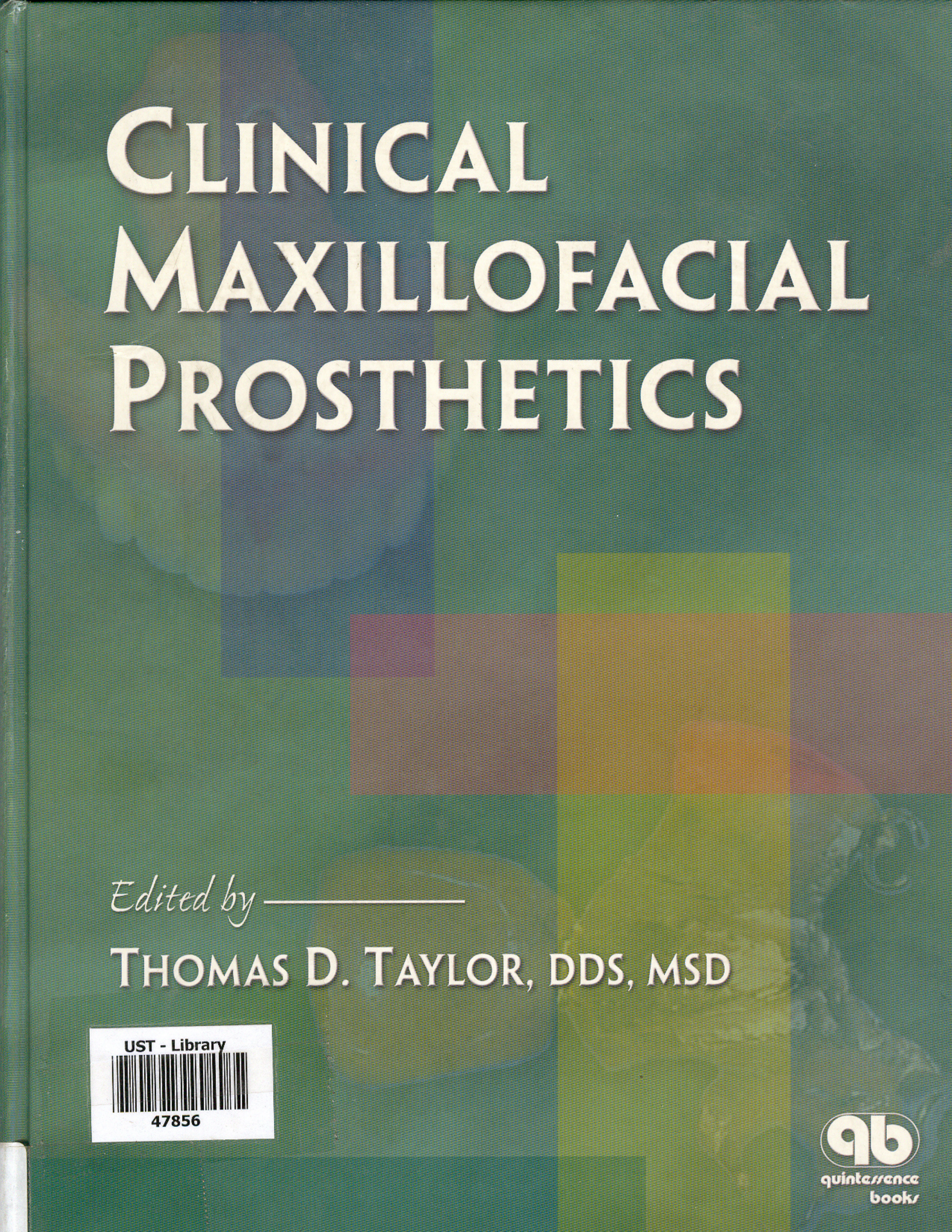

CLINICAL MAXILLOFACIAL PROSTHETICS

Edited by

THOMAS D. TAYLOR, DDS, MSD

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CLINICAL MAXILLOFACIAL PROSTHETICS

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Foreword

Following World War II, an era of specialization among health care professionals ensued. In dentistry, medicine, and surgery, specialists were trained to keep pace with the rapidly growing body of knowledge that evolved from new developments in diagnosis, treatment methods, instrumentation, materials, and technology. As a subspecialty area of the recognized dental specialty prosthodontics, maxillofacial prosthetics has become an essential patient-care link between dentistry and surgery.

Because patient populations and life expectancy have increased, the need for maxillofacial prosthetic services has also grown. While much of this treatment must necessarily be provided in hospital settings, the technology and economic aspects of patient care have altered previous traditional approaches to its provision. Having undergone some evolutionary change, the principles, concepts, and practices applicable to prosthodontic treatment still constitute the fundamental basis for sound maxillofacial prosthetic therapy. The underlying intent of this book, as succinctly expressed by the author in his preface, reflects cognizance of those factors and endeavors to facilitate their application by whomever and wherever the services are being provided.

To enunciate the scope of prosthodontic procedures and techniques involved in maxillofacial treatment, an impressive roster of contributors has been assembled. All have acknowledged expertise and broad experience in clinical practice. Detail and depth of information related to the clinical application of specific topics addressed in the book chapters should enable the interested reader to appropriately treat or refer the potential patient for needed services.

This work provides a logical collection and elucidation of pertinent intra- and extraoral subject matter as an excellent current reference resource and addition to the maxillofacial prosthetic literature.

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Preface

The subspecialtv of maxillofacial prosthetics currently finds itself experiencing more change than at any other time over the past 50 years of its recognized existence. Advances in surgical and therapeutic modalities for the treatment of patients with head and neck malignancy, post-tumor therapy surgical reconstruction, and congenital and developmental defects have challenged traditional prosthodontic principles for the management of the many patients needing our services. The ranks of those providing traditional maxillofacial prosthetic services have expanded to include prosthodontists, general and hospital dentists, and others not formally trained in the subspecialty. The practice of maxillofacial prosthetics has also been dramatically impacted by third parties not directly involved with the provision of patient care but whose activities dramatically affect our ability to treat. These concerns, changing treatment philosophies and methods, and the challenge of practicing maxillofacial prosthetics in private practice as well as in institutional environs were the impetus for creating this book. A conscious decision was made to focus on the “how to” rather than the historical basis for treatment or the medical background of involved disease processes.

A number of excellent texts have been written on the subject of maxillofacial prosthetics. By review of my own library, at least nine full texts have been dedicated to the subject in the past 50 years. They have addressed the subspecialty and have to a greater or lesser degree also dealt with the medical management of patients whose circumstances require maxillofacial prosthetic care. The drawback of this approach has been a tendency to oversimplify medical/surgical treatment or to narrowly focus on the therapeutic philosophy and protocol of specific medical centers without addressing the full extent of accepted treatment modalities and philosophies. Medical/surgical modalities for the treatment of congenital, developmental, and acquired maxillofacial defects frequently change so rapidly that the therapies described in texts on maxillofacial prosthetics are often outdated by the time the book is published. To address these problems, this book has been written with a focus on the prosthodontic aspects of care for our patient population. For a review of the etiology, pathology, or therapeutic management for a specific type of tumor or congenital defect, the reader is directed to books or journals that deal primarily with such procedures.

This book is an in-depth review of prosthodontic procedures as they are applied in the maxillofacial situation. The subspecialty of maxillofacial prosthetics is frequently practiced by prosthodontists and occasionally by general dentists in a hospital environment who have not had the benefit of formal training in the subspecialty. It is hoped that this book will be of use to those individuals by serving as a “how-to” reference emphasizing prosthodontic procedures while minimizing surgical/medical considerations that can more appropriately be found elsewhere. To that end, *Clinical Maxillofacial Prosthetics* is written as a user’s guide to commonly occurring maxillofacial prosthetic challenges. This approach is based upon careful discussion of both general and specific prosthodontic principles and techniques rather than on numerous case reports of limited value to the general reader.

I would like to acknowledge the various chapter authors, some 25 of them, whose efforts have made this text an outstanding contribution to the subspecialty. Each author was recruited because of recognized expertise in a particular topic area. I am indebted to their dedication, their interest, and their energy in making this text a reality and in making it such a substantial addition to the prosthodontic literature. Heartfelt thanks to each and every one.

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Psychological Management of the Maxillofacial Prosthetic Patient

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In the process of recording a patient's chief complaint, present and past illness, medical and dental history, diagnostic records and tests, examination, and adjunctive consultations, the health care provider mentally assesses the patient's demeanor. Such assessment is necessary to ascertain whether the proposed prosthodontic treatment may be performed efficaciously or understood and appreciated by the patient once it is completed. The prognosis for a successful treatment outcome is dependent upon the prosthodontist making a correct diagnosis and anticipating issues beyond the realm of dentistry alone.

The health care provider in the process of patient evaluation assesses the attitude, demeanor, and/or behavior of the patient and attempts to classify his or her mental status. Patient classifications in and of themselves may offer the clinician a rubric that is critical to patient management and treatment planning. However, it is more important to understand the etiology of behaviors and its potential impact upon the treatment process in order to implement the appropriate care.

Psychological Classification and Interpretation

Prosthodontists often use House's (1978) classifications of *philosophical*, *exacting*, *indifferent*, and *hysterical* to categorize the mental status of patients. This approach may be meaningful for the typical prosthodontic patient, but it may fall short in classifying those patients with life-threatening diseases or who have suffered recent traumatic events. Additionally, those patients in whom the face is disfigured and/or those who have lost an important biological function such as speech or swallowing will experience changes in social acceptance that impact the psyche and sense of well-being. The "philosophical" patient, the one who cognitively understands and is rational or who appreciates the prosthodontic treatment being attempted, may abruptly change demeanor upon the challenge of ablation of an extensive facial cancer or a surgical/prosthetic reconstructive outcome that is less than desirable.

As the maxillofacial patient's quality of life is altered and social integration becomes difficult, the patient's expectations to return to "normalcy" often collapse. Underlying emotional issues that were subconsciously buried may come to the surface, or unachievable expectations and unreasonable demands may arise that hinder the prosthodontist's ability to provide adequate treatment. Further, in such a case it is critical for the prosthodontist to assess whether treatment should be performed at all, delayed until the patient's demeanor is more conducive to treatment, and/or coordinated with services of supportive professionals such as social workers or psychologists (Gillis, 1979).

The prosthodontist’s goal is a successful treatment outcome, but not at the expense of one’s emotional and mental well-being or that of staff. A health care provider is not required to “heal” every patient who walks through the front door. This principle applies to all patients, whether a traditional prosthodontic patient, a temporomandibular disorder patient, or a maxillofacial prosthetic patient. In practice, this principle means that if at the examination level one recognizes a patient with underlying psychological conditions or confounding emotional factors, it may be best to not treat until these are addressed. If treatment commences without the fundamental controls or sufficient rapport in place, the clinician is likely to wonder in the middle of treatment how tilings ever went awry and regret that treatment ever began. There must be an unconditional commitment to the same treatment goals by both doctor and patient. Therefore, it becomes paramount that the prosthodontist understand the various psychological diagnoses, ranging from subtle emotional nuances to overt psychological disorders, that potentially undermine successful prosthodontic treatment.

The types of psychological impairments that may be anticipated are outlined below. While these summaries are not exhaustive, they can add to any prosthodontist’s knowledge base. The ability of the practitioner to recognize these impairments will facilitate total patient care. Psychological changes that can occur in maxillofacial patients follow with directives presented on the various methods of referral to improve the patient’s mental status prior to treatment.

General Psychological Impairments

The purpose of this section is to provide the prosthodontist with a general understanding of the range of psychological disorders that may be experienced by patients. This section is not intended to be a detailed explanation of all of the disorders described by the American Psychiatric Association. Psychological impairments are characterized by disturbances in a person’s thoughts, emotions, or behavior. These impairments can range from those that cause mild distress to those that severely impair a person’s ability to function individually, in a family, or in a community. Some individuals with acute impairments require hospitalization because they become unable to care for themselves or because they are at risk of harming others or themselves. Most people, however, can recover from mental illness and return to normal lives with appropriate referral and treatment.

Distribution

Mental illness affects people of all ages, races, cultures, and socioeconomic classes. In the United States, researchers estimate that about 24% of people 18 or older, or about 44 million adults, experience a mental illness or substance-related disorder during the course of any given year. The most common of these disorders arc depression, alcohol dependence, and various phobias (irrational fears of things or situations). In any given year an estimated 2.6% of adults in the United States, or about 4.8 million people, suffer from a severe and persistent mental illness such as schizophrenia, bipolar disorder, or a severe form of depression or panic disorder. An additional 2.8% of adults, or about 5.2 million people, experience a mental illness that seriously interferes with one or more aspects of daily life, such as the ability' to work or to relate to other people. Please note that all of these figures exclude people who are homeless and those living in prisons, nursing homes, or other institutions—populations that have high rates of mental illness. International surveys have demonstrated that from 30% to 40% of people in a given population experience a mental illness during their lives. These surveys have also revealed that anxiety disorders are usually more common than depression.

In children and the elderly, rates and forms of mental illness change with age and gender. For example, depression and anxiety disorders occur at the same rate among girls and boys until mid-adolescence, when girls account for more of the case histories. Among prosthodontic patients, children most often present with congenital delects or alterations in growth and development, whereas adolescents and young adults often present with developmental defects or trauma. Mental illness among the elderly has grown significantly as a greater percentage of people live beyond the age of 65, both in the industrialized nations of the West and in the developing countries of Asia, Africa, and Latin America. Dementia, characterized by impaired intellectual functioning and memory loss, occurs mostly among the elderly and may overlap with the ablative cancer patient groups.

Like physical diseases, the highest rates of mental illness occur among people in the lower socioeconomic classes, especially those living in severe poverty-. Rates of almost all mental illnesses decline as levels of income and education increase. The hardships associated with poverty seem to contribute to the development of some mental illnesses, particularly anxiety disorders and depression. In addition, debilitating mental illnesses, such as schizophrenia, may cause individuals to shift to lower socioeconomic classes. The ability of maxillofacial patients to integrate into society' and to be employable will be critical to their mental status. The overall prevalence rates of mental illnesses among men and women are similar. I Iovvever, men have much higher rates of antisocial personality disorder and substance abuse. The acquired maxillofacial cancer/defect population may correlate with substance abuse. In the United States, women suffer from depression and anxiety disorders at about twice the rate of men. The gender gap is even wider in some countries. For example, women in China suffer from depression at nine times the rate of men.

Anxiety Disorders

Anxiety disorders involve excessive apprehension, worry, and fear. More than 16 million adults ages 18 to 54 in the United States suffer from anxiety-' disorders, which include panic disorder, obsessive-compulsive disorder (OCD), posttraumatic stress disorder (PTSD), social phobia, and generalized anxiety disorder. People with generalized anxiety disorder experience constant anxiety about routine events in their lives. Phobias are fears of specific objects, situations, or activities. Panic disorder is an anxiety' disorder in which people experience sudden, intense terror and physical symptoms such as rapid heartbeat and shortness of breath.

Panic disorder affects about 1.7% of the US adult population ages 18 to 54, or 2.4 million people, in a given year. Panic disorder typically strikes in young adulthood. Roughly half of all people who have panic disorder develop the condition before age 24. Women are twice as likely as men to develop panic disorder. People with panic disorder may also suffer from depression and substance abuse. About 30% of people with panic disorder abuse alcohol and 17% abuse drugs such as cocaine and marijuana. About one third of all people with panic disorder develop agoraphobia, an illness in which they become afraid of being in any place or situation where escape might be difficult or help is unavailable in the event of a panic attack.

Patients with obsessive-compulsive disorder experience intrusive thoughts or images (obsessions) or feel compelled to perform certain behaviors (compulsions). About 2.3% of the US adult population ages 18 to 54, approximately 3.3 million Americans, have OCD in any given year. OCD affects men and women with equal frequency.

Patients with posttraumatic stress disorder relive traumatic events from their past and feel extreme anxiety and distress about the event. In the United States, about 3.6% of adults ages 18 to 54, or 5.2 million people, have PTSD during the course of a given year. PTSD can develop at any age, including childhood. PTSD is more likely to occur in women than in men. About 30% of men and women who have spent time in war zones experience PTSD. The disorder also frequently occurs after violent personal assaults, such as rape, mugging, or domestic violence; terrorism; natural or human-caused disasters; and accidents. Depression, alcohol or other substance abuse, or another anxiety disorder often accompanies PTSD.

About 3.7% of American adults ages 18 to 54, or 5.3 million people, have social phobia in any given year. Social phobia occurs in women twice as often as men, although a higher proportion of men seek help for this disorder. The disorder typically begins in childhood or early adolescence and rarely develops after age 25. Social phobia is often accompanied by depression and may lead to alcohol or other drug abuse.

Mood Disorders: Depression and Mania

Mood disorders, also called affective disorders, create disturbances in a person’s emotional life. Depression, mania, and bipolar disorder are examples of mood disorders. More than 19 million adult Americans will suffer from a depressive illness—major depression, bipolar disorder, or dys- thymia—each year. Many of them will be incapacitated for weeks or months because their illness is left untreated.

Nearly twice as many women (12%) as men (7%) are affected by a depressive illness each year. Depression is a frequent and serious complication that follows heart attack, stroke, diabetes, and cancer, but it is very treatable. Further, depression increases the risk of having a heart attack. According to one recent study that covered a 13- year period, individuals with a history of major depression were four times as likely to suffer a heart attack compared with people without such a history. Symptoms of depression may include feelings of sadness, hopelessness, and worthlessness, as well as complaints of physical pain and changes in appetite, sleep patterns, and energy level. In mania, on the other hand, an individual experiences an abnormally elevated mood, often marked by exaggerated self-importance, irritability, agitation, and a decreased need for sleep. In bipolar disorder, also called manic-depressive illness, a person’s mood alternates between extremes of mania and depression. More than 2.3 million Americans ages 18 and over, about 1% of the population, suffer from manic-depressive illness. As many as 20% of people with manic- depressive illness die by suicide. Men and women are equally likely to develop manic-depressive illness.

Schizophrenia and Other Psychotic Disorders

People with schizophrenia and other psychotic disorders lose contact with reality. Symptoms may include delusions and hallucinations, disorganized thinking and speech, bizarre behavior, a diminished range of emotional responsiveness, and social withdrawal. In addition, people who suffer from these illnesses experience an inability to function in one or more important areas of life, such as social relations, work, or school. More than 2 million adult Americans are affected by schizophrenia. In men, schizophrenia usually appears in the late teens or early twenties. Onset of the disorder in women is usually in their twenties to early thirties. Schizophrenia affects men and women with equal frequency. Most people with schizophrenia suffer chronically throughout their lives. One of every 10 people with schizophrenia eventually commits suicide.

Personality Disorders

Personality disorders are mental illnesses in which one’s personality results in personal distress or a significant impairment in social or work functioning. In general, people with personality disorders have poor perceptions of themselves or others. They may have low self-esteem or overwhelming narcissism, poor impulse control, troubled social relationships, and inappropriate emotional responses. Considerable controversy exists over where to draw the distinction between a normal personality and a personality' disorder. In addition, treatment for this disorder is typically long term, though success is not extremely difficult to achieve.

Cognitive and Dissociative Disorders

Cognitive disorders, such as delirium and dementia, involve a significant loss of mental functioning. Dementia, for example, is characterized by impaired memory and difficulties in such functions as speaking, abstract thinking, and the ability to identify familiar objects. The conditions in this category usually result from a medical con dition, substance abuse, or adverse reactions to medication or poisonous substances.

Dissociative disorders involve disturbances in a person’s consciousness, memories, identity, and perception of the environment. Dissociative disorders include amnesia that has no physical cause; dissociative identity disorder, in which a person has two or more distinct personalities that alternate in their control of the person’s behavior; depersonalization disorder, characterized by a chronic feeling of being detached from one’s body or mental processes; and dissociative fugue, an episode of sudden departure from home or work with an accompanying loss of memory. In some parts of the world, people experience dissociative states as possession by a god or ghost. In many societies, trance and possession states are normal parts of cultural and religious practices and are not considered dissociative disorders.

Somatoform and Factitious Disorders

Somatoform disorders are characterized by the presence of physical symptoms that cannot be explained by a medical condition or other mental illness. Physicians often conclude that such symptoms result from psychological conflicts or distress. In conversion disorder, also called hysteria, a person may experience blindness, deafness, or seizures, yet a physician can find nothing wrong with the person. People with another somatoform disorder, hypochondriasis, constantly fear that they will develop a serious disease and misinterpret minor physical symptoms as evidence of illness.

In contrast to people with somatoform disorders, people with factitious disorders intentionally produce or fake physical or psychological symptoms in order to receive medical attention and care. For example, an individual might falsely report shortness of breath to gain admittance to a hospital, report thoughts of suicide to solicit attention, or fabricate blood in the urine or the symptoms of rash so as to appear ill.

Substance-Related Disorders

Substance-related disorders result from the abuse of drugs, side effects of medications, or exposure to toxic substances. These disorders arc regarded as behavioral or addictive disorders rather than as mental illnesses, although substance-related disorders commonly occur in people with mental illnesses. Common substance-related disorders include alcoholism and other forms of drug dependence. Drug use can contribute to symptoms of other mental disorders, such as depression, anxiety, and psychosis. Drugs associated with substance-related disorders include alcohol, caffeine, nicotine, cocaine, heroin, amphetamines, hallucinogens, and sedatives.

Eating Disorders

Eating disorders are conditions in which an individual experiences severe disturbances in eating behaviors. People with anorexia nervosa have an intense fear of gaining weight and refuse to cat adequately or to maintain a normal body weight. People with bulimia nervosa repeatedly engage in episodes of binge eating, usually followed by self- induced vomiting or the use of laxatives, diuretics, or other medications to prevent weight gain. Eating disorders occur mostly among young women in Western societies and certain parts of Asia.

Impulse Control Disorders

People with impulse control disorders cannot control an impulse to engage in harmful behaviors such as explosive anger, stealing (kleptomania), setting fires (pvromania), gambling, or pulling out their own hair (trichotillomania). Some mental illnesses such as mania, schizophrenia, and antisocial personality disorder may include symptoms of impulsive behavior.

Psychological Changes in the Maxillofacial Patient

Maxillofacial patients are often classified by the etiology of their diagnosis, which is usually divided into three categories: acquired, congenital, and developmental defects. A certain percentage of maxillofacial patients, in addition to having a maxillofacial defect, may have had pre-existing psychological impairments that may further confound their treatment. Others may have been psychologically stable before the event that created the “loss” but afterward experience some measure of psychological instability.

Acquired Defects

Patients with acquired maxillofacial defects have had ablative cancer surgery or severe trauma. These two groups arc similar in that in both situations a person who had relatively normal anatomy and physiologic function subsequently lost them overnight. Cancer patients differ from trauma patients, however, in some important ways. The cancer patient may express “why me?” and is often faced with the possibility of recurrence, more surgery, chemotherapy or radiotherapy, and the futility of the process. Patients with smaller defects frequently will be more demanding and have higher expectations than patients with larger, more debilitating defects. The trauma patient is usually younger than the cancer patient, particularly if the trauma is self-inflicted. It is remarkable when treating near-suicides to note that their demeanor often appears relatively, but superficially, upbeat. Additionally, with the self- inflicted trauma patient, there is a *la belle indifference* demeanor when confronted with the upward struggle of multiple, difficult surgical procedures to restore the patient’s face.

Congenital Defects

Those patients with maxillofacial birth defects intuitively understand that they are different from the norm and may believe that they are genetically damaged or subhuman. They may not fit in with their peer or age groups. They face the knowledge that there may be a genetic predisposition to recurring incidence in their own progeny. Parents may have difficulty in accepting their child or may blame themselves for the birth defect, resulting in family dysfunction and loss of family unity. Congenital maxillofacial patients usually face multiple and sequential surgeries, orthodontics, and prosthetic procedures over several years in an attempt to correct their defects. In cleft lip and palate patients one would expect some variation, as the defect may range from a simple cleft lip with minor loss of function to bilateral cleft lip and palate with severe impairment in swallowing, speech, and facial esthetics. Craniofacial anomaly patients are at risk for learning disorders and for internalizing and externalizing behavior problems.

Developmental Defects

Anomalies in growth and development may not be readily apparent at first in the developmental defect patient but will ultimately become so. The developmental defect patient may display emotional responses similar to the patient with congenital defects. Because the developmental defect patient is one in whom the defect becomes apparent over time, the patient may or may not learn to deal with the evolving process.

Loss and Grief in Maxillofacial Defects

Once patients realize they have cancer, or have experienced some other debilitating crisis creating a loss, they will perceive it as both an immediate and future loss. This loss may manifest itself in the form of anxiety', depression, or a posttraumatic stress disorder. In any event, a cycle of loss, grief, and reintegration must be completed by the patient and understood by the prosthodontist.

Loss

Loss has been defined as “a state of being deprived of or being without something one has had and valued” (Peretz, 1970). The loss of a facial feature or other body part due to cancer can be one of the most painful experiences in life. This loss includes not only the deprivation of the feature, but also subsequent deprivation of some life experiences. Patients will be subject to possible rejection by their spouses, friends, business associates, and their community. In addition, the loss of a maxillofacial feature may mean a loss of status in social groups or in one’s career. If patients cannot develop successful psychological and physical coping skills, they may experience severe psychological trauma, even if the loss appears minimal.

Peretz (1970) divides loss into four categories: loss of a significant person, loss of a part of the self, loss of material objects, and developmental loss. The meaning of the loss depends on the one who feels the effect. Loss can threaten the integrity of one’s self-esteem, which will remain easily damaged for some time after the fact. Even the threat ofloss can be emotionally devastating. It can trigger the fear of death at the deepest level.

Grief

Stages of the grief process include:

- *Shock and denial.* Changes occur in sleeping and eating, often symptomatic of depression. The past is idealized. Patients arc at risk for suicide if their depression is severe.
- *Guilt, anger, and a search to find ways to discharge the emotional pain.* The feeling of anger at this stage is really secondary to the driving feeling of fear of the unknown and unfamiliar. The patient may be subject to possible substance abuse.
- *Adjustment, acceptance, and growth.* The patient comes to realize that the past had its faults and the future may not be so bad. This stage signals acceptance of the loss, healthy adjustment, and new life patterns. Integration of the prosthesis is possible.

The reaction of grief is an adaptive function “to assure group cohesiveness in species where a social form of existence is necessary for survival” (Avcrill, 1975). Unfortunately, because our society emphasizes competency, adequacy, and strength, this often prevents patients from sharing their feelings.

Prosthodontists will do well to recognize their own past losses and grief and refer patients who need validation to trained helping professionals. In most cases, the prosthodontist will not have had to experience the same level ofloss as the patient, but remembering losses of loved ones, friends, and property will help the practitioner to be empathetic with the patient and to be in a better position from which to gauge the patient’s psychological progress. Consequently, this empathy will assist the prosthodontist in making a decision regarding a referral to a psychotherapist. At the same time the prosthodontist will need to be wary of any unresolved grief that may be triggered in response to the patient’s grief experience.

Regardless of how effectively grieving is done, it cannot be rushed. Grieving requires time out from routine living and often makes the one grieving appear disturbed. Improper recognition of this can cause prosthodontists to misinterpret behavior and add confusion to the suffering. This can create a lack of self-confidence in patients, weaken their sense of self, bring despair, or trigger self-destructive behavior. Grief is the opposite of what is considered to be mental health—the ability to cope, to love, and to work. Grief can cause physical illness, poor judgment, weakened inhibition, clouded intellect, and blurred perception. Patients who experience traumatic losses will experience great ambivalence between wanting to be alone and wanting companionship. They will also struggle with wanting to be active and passive, dependent and independent, exploitive and helpless. Grief is so overwhelming that it has often been viewed as an illness that may end in onlv.partial recovery. This partial recovery, or unresolved grief, can be triggered, even after a significant amount of time following the initial loss, by other losses or become the impetus for a range of physical or mental disorders.

Therapy for children in such cases is strongly indicated. Children often grieve their losses openly, and a dominant emotion for children toward a loss is anger. Due to their egocentricity, children can often blame themselves for losses and feel guilty. Improperly discharged, guilt and anger can set the stage for later emotional difficulties as adolescents and adults.

Impact of Psychological Impairments

The maxillofacial patient's quality of life is obviously impacted, which predisposes him or her to a variety' of psychological impairments. Recent studies into the quality of life (QOL) of patients afflicted with a variety of disease processes have been performed (Guvatt et al, 1993; Chandra et al, 1998). QOL surveys may be used to measure cross-sectional differences in the quality of life between patients at a point in time or longitudinal changes within patients over a period of time. The American Academy of Maxillofacial Prosthetics is currently investigating the quality of life of the maxillofacial patient. Interestingly, preliminary results reveal that patients' perspectives on their quality of life may be significantly different from what the prosthodontist believes is important. While the health care provider may focus on the precision of the treatment, the patient may be more interested in acceptance and reintegration into society. Further research in this emerging area is forthcoming.

Psychometric testing may be considered, including the Minnesota Multiphasic Personality Inventory, Cornell Medical Index, Eysenck Personality Inventory, and Social Adjustment Rating Scale, but the administration may best be left to those who use psychometric instruments on a daily basis (Laney and Gibilisco, 1983). Patients will inquire as to the interpretation of the inventory instruments and demand an explanation of the results. The prosthodontist may sense by the patient's presentation (attitude, demeanor, appearance, emotional state, mood, manner of speech, and cognitive processes) the nature of the psychological impairment and then make the appropriate referral for definitive evaluation using the methods described later in this chapter.

The disorders mentioned earlier will have varying effects on the patient's ability to withstand surgical procedures or to accept prostheses. It should also be noted that the degree of severity of the disorder may also be a factor in the patient's successful treatment. The practitioner would be well advised to consult with a social worker, psychologist, or psychiatrist as a part of the treatment team to aid in preparing a plan that will achieve the desired goal of the patient.

Without a complete assessment of the patient it is difficult to project the reaction that a patient might have to the surgical procedure or the placement of a prosthesis. However, understanding the disorders and their symptoms will aid the practitioner in anticipating various kinds of behaviors. It should be strongly noted that the quality and content of the communication between the prosthodontist and the patient significantly affects the patient's ability to accept the prosthesis and the successful outcome of the treatment plan.

Clinician Referral

Family Support

Family support and patient-centered treatment involve knowing how to enlist the support of the patient's family and significant others in the treatment and aftercare process. Support from family and friends can be a great help in coping with trauma. Patients may feel isolated and lonely. Connections with other people who care and try to understand can help the patient overcome this isolation. Treatment professionals can support this process by encouraging families to learn about the trauma, the prosthesis, and how to help their family member. Family support usually has a positive impact on an individual recovering from such experiences.

This connection between individuals with cancer, or other trauma, and their families is often overlooked in treatment. Medical treatments focus on helping the individual to battle the disease, while psychological treatments focus on helping the individual handle emotional distress. Family therapists understand that families are groups just like other groups in society in that they operate according to certain rules, have certain values and beliefs, and have certain ways of communicating with each other. Families need to achieve a state of homeostatic balance to succeed and progress.

After a diagnosis of cancer or the realization of the degree of the maxillofacial trauma, the structure of the family can be greatly changed. Communication patterns can be disrupted. People may be afraid to say things to each other in the same way they did before. The balance of power in the family can be affected. Family therapy by a trained professional can help the patient and family regain their homeostasis in the wake of maxillofacial surgery or trauma. A practitioner should be supportive of the family that surrounds the patient and should provide them with as much education as possible. Referral to a trained family therapist is appropriate if one suspects that their homeostatic balance is being jeopardized. Above all, listen to the patient.

Patient-Centered Treatment Planning

Patient-centered planning is not a new concept in the social sciences; however, it is antithetical to treatment plans that are composed without the expressed wishes and input of the patient and family. It is widely accepted that patients' problems can be impacted positively by their family, their community, and other clinics/agcncies with which they are involved. A priori concepts in patient-centered planning dictate that the individual will direct the planning process with a focus on what he or she wants and needs. Professional staff will play a role in the planning and delivery of treatment and may play a role in the planning and delivery of supports. Care strategies play an important role in planning for and delivery of supports, services, and treatment. Patient-centered planning fits well with these strategies. Both strategies attempt to ensure that individuals are provided with the most appropriate services necessary to achieve the desired outcomes. Patient-centered planning is a highly individualized process designed to respond to the expressed needs and desires of the individual. Each individual has strengths and the ability' to express preferences and to make choices. The individual's choices and preferences should always be considered, if not always granted. Treatment and supports identified through the process should be provided in environments that promote maximum independence, community connections, and quality' of life. A person's cultural background must be recognized and valued in the decision-making process.

Mental Health Services

Before consulting or referring a patient to mental health professionals, practitioners must know if their patient is at a stage of acceptance of their maxillofacial deficiencies to accept referrals. If this is not the case, any referral will be met with immediate rejection and a positive outcome of the prosthetic procedure will be doubtful.

There are different disciplines that play a role in mental health services. Social workers are trained to provide psychotherapeutic or case management services to the patient. They may differ in their views from psychologists in that their view of the client involves the client's family and environment and will typically involve these areas in treatment planning. Psychologists may be more psychodynamic or individually focused than social workers. Psychiatrists are specialized physicians and are the only mental health practitioners who can prescribe medication.

There are different levels of care in mental health to which to refer patients. Each level increases the level of restriction to the patient. While the field of mental health is continually changing, Table 1 1 may provide the practitioner with a basic understanding of interventions that are available to the patient.

Table 1-1 Levels of Care

Support groups	Groups for patients or their families typically facilitated by other patients who are familiar with the trauma or problem. The goal of this intervention is to provide support to the group member experiencing the trauma.
Educational groups	Groups for patients or their families used to educate on the trauma or problem area, facilitated by a trained professional. The goal of this intervention is to educate; it is not intended for treatment.
Outpatient therapy	Psychotherapy for individuals and their families with a goal of decreasing symptoms and coping with life changes. This intervention is provided by trained professionals in their offices over a regular schedule of appointments.
Home-based treatment	Psychotherapy for chronic individuals and their families with a goal of decreasing symptoms and coping with life changes. This intervention is provided by trained professionals in the homes and community of the client at any time, including 24- hour emergency care. In this approach, other professionals and disciplines work together to provide the treatment.
Day treatment	Daily psychotherapeutic treatment in an educational setting with all disciplines involved. This level of care is designed for those chronic individuals who need continual availability to therapists and doctors but may also benefit from skill development.
Partial hospitalization	Daily psychotherapy within a hospital setting for those chronic individuals who need daily supervision by therapists and doctors but can be successful in returning home in the evening.
Inpatient hospitalization	Psychiatric hospitalization for those individuals who are in danger of hurting themselves or others.

Patient Support Groups

Practitioners may, as part of the course of treatment, include a referral to a support group for the patient and/or the family. These groups can aid in patients' acceptance of their afflictions and treatments. Consequently, this acceptance will aid in a positive prognosis and outcome of the treatment intervention. Some support groups include:

- About **Face,** an international organization that provides emotional support and information to individuals who have facial differences and their families. About Face is recognized by the Cleft Palate Foundation of the American Cleft Palate-Craniofacial Association as the leading support organization for individuals and families whose lives are affected by facial difference. About Face can be reached at 99 Crowns Lane, 4th Floor, Toronto, Ontario, M6TI 3M8, Canada, or phoned at 800-665-FACE.
- **Support for People with Oral and Head and Neck Cancer, Inc.,** a patient-directed self-help organization dedicated to meeting the needs of oral and head and neck surgery and cancer patients. They can be reached at PO Box 53, Locust Valley, NY 11560-0053, or phoned at 516-759-5333.
- **Let's Face It,** an information and support network for people with facial difference, their families, friends, and professionals. They publish an annual 5.0-page booklet with more than 150 resources for people with facial disfigurement. They can be reached at Box 29972, Bellingham, WA 98228-1972, or phoned at 360-676-7325.

Illustrative Patient Histories

Three patients were interviewed to illustrate several key points and concepts.

Patient 1: AB

AB is a female Caucasian, age 13, who was diagnosed with a right pterygopalatine parameningeal embryonic rhabdomyosarcoma at age 3 *A.* Initially, pediatricians diagnosed her as having the mumps. However, the increase in swelling motivated her mother to obtain additional assessments at a local children's hospital. The patient received 6,300 CGy of radiation therapy and 2 *'A* years of chemotherapy. She is now cancer free. As a result of her treatment, the maxillary and mandibular growth centers were interrupted. Additional findings were partial anodontia, unerupted teeth, and morphogenic changes in the dentition as well as velopharyngeal incompetencv. Growth hormone treatment was carried out from 1994 to 1999. Currently she is edentulous in the maxillary arch and has three remaining teeth in the mandibular arch. There is an obvious disproportionate facial relationship.

The patient does not remember anything other than having a growth problem. She was very alert during the interview and polite, answering questions when asked and sometimes spontaneously adding to her mother's answers. The patient was smiling and appeared positive during the interview. She is in the eighth grade and enjoys playing basketball for her church, dancing, and watching television. When asked about the number of friends she has, she reported “about 20.” Upon further probing, she said that she has four or five close friends to whom she can tell confidential things. When asked to describe her current quality of life on a scale of 1 to 10, she answered 9. Discussing her rating further, she explained that “10 is perfect and nobody's perfect.” This assertion did not appear to be a defensive mechanism. The patient was rather positive and forthright with the answer and perhaps revealed a way for her to cope with her illness. The patient is anticipating looking different, talking differently, and eating faster with her new prosthesis. She recommends that physicians use listening and empathy with their patients to really understand what they are experiencing.

She denied any depression recently or in the past. Her mother reported how the family had to reorganize around her daughter's illness and treatments, but they did not react negatively to the reorganization. The patient felt that she got through the illness and the treatments because of the support of her family. Her mother felt that she personally got through this event with the support of her family and the support of the other parents with children in similar trauma. There were some tears in her eyes when she talked about this support. It was quite evident that family and peer support was a critical factor in the positive way the patient was getting through the ordeal. The patient's mother was instrumental in establishing annual supportive events for the families and children receiving the treatment within the same clinic as her daughter. In addition, the mother noted the importance of taking time for short vacations with her husband to re-energize. She reports taking each day as it comes.

Patient 2: JP

JP is a female Caucasian, age 25, born with an arteriovenous malformation (AVM) of the midface. The malformation developed over time resulting in the vessels and capillaries enlarging in her brain and face and creating a life-threatening situation. Her series of coagulotherapy and surgeries began as a late teen. As a result of ablative surgeries, the patient lost her check, nose, maxilla, right orbital floor, and malar process. The inoperable intracranial AVM remains and poses an impending fatal outcome. Besides the obvious loss of facial esthetics there was an inability to masticate, swallow, or articulate speech. Lack of saliva and mucous control created further difficulties for her socially. The patient entered into a deep depression following surgery. Alter this time she attempted to carry on as normal a routine as possible despite the medical appointments. Maxillofacial prosthetic treatment included the construction of a maxillary obturator and an implant-retained facial prosthesis.

When she was told of the terminal nature of her illness at age 16, JP did not believe it and did not want to accept the illness. She experienced major depression and subsequent depressive neurosis, which lasted for 6 years with many of the classic features described earlier. She had suicidal ideation but did not consider suicide an option, largely due to her religious convictions and the support from her friends. She finally accepted her illness and her subsequent treatment.

JP is the oldest of three siblings in her family. She reported that her father was an alcoholic, perhaps as a way to cope with JP’s illness, and that her family was very dysfunctional. Her parents divorced in 1982 when she was 8 years old. Both of her parents blamed themselves for JP’s illness and expressed anger about this guilt, often toward their daughter in both psychological and physical ways. Her mother “lost her grip on reality"” and began to physically abuse her, ultimately kicking JP out of the home at 18 years of age. JP eventually moved in with a friend of her mother’s and was planning a move to her own apartment at the time of this interview. Her relationship with her mother has since improved.

Despite these difficulties, JP is currently attending a local community college studying drama, literature, and computers. She professed a desire to be a spokesperson for her illness. She walks 30 to 60 minutes a day and reports that she has many friends and is active in her church. She rates her quality of life as very high at this time, anticipating improvements that are being made to her prosthesis. She reported that her religious faith has helped her and she relics on this faith to carry her through each step in the process of her treatment. It should be noted that JP credited the empathy and understanding of the practitioners who treated her as a significant factor in her treatment. She is very positive about her immediate prognosis, despite the terminal nature of her illness. In fact, she has more drive and zeal for life than many other people without maxillofacial defects.

Patient 3: JF

JF is a male Caucasian in his early 60s with a diagnosis of a squamous cell carcinoma of the right sinus and maxilla. The ablative surgery resulted in the removal of the eye, orbital contents, and right maxilla. Additionally, a full course of external- beam radiation was administered. Xerostomia and trismus were confounding problems in the treatment. Facial esthetics were compromised and there was an inability' to masticate, swallow, or articulate speech. Hyperbaric oxygen therapy was scheduled in an attempt to improve the outcome of his bone grafting and implant placement in the remaining maxilla, the mandible, and the orbital regions. Maxillofacial prosthetic treatment included a fixed implant prosthesis for the mandibular arch, an implant-retained and supported maxillary obturator, and an orbital prosthesis affixed to craniofacial implants.

It was clear in this interview that JF was thoroughly educated about his illness. JF credits his religious faith and the support of friends and family' with helping him cope with his illness and recovery'. He related information about his grandmother who had contracted polio at age 3. She got married, had two children, and was able to complete housekeeping responsibilities. Her positive state of mind had helped her cope and she had not felt that she was handicapped.

JF was very upbeat during the interview and told several humorous stories about life with his prosthesis, indicating a high level of acceptance. He reports going through all of the stages of loss and grief when he learned of his illness and subsequent surgery. In fact, when he arrived at the acceptance stage, after a short depression of about a week, he decided to “beat this thing” and reports being the one who motivated his family to this stage as well.

JF reports that during the surgery to remove the cancer, it did not appear to him that his doctors understood the value of educating the patient as to what to expect. When his hard palate was removed, the patient could not communicate or eat and could only open his mouth 10 mm. He had difficulty finding things to eat, lost weight, and rated his quality of life at that time as a 2 out of 10. He credits his will to live, learned from his parents, and his faith in God as motivational forces that helped him through that difficult time.

His maxillofacial treatment allows JF to drive his car, cut his grass, and travel often. He reports that he can eat a wide variety of items and has a satisfying social life. JF advises practitioners to educate and listen to their patients. In addition, he recommends support groups for all similar patients and their families.

Review and Conclusions

Some of the factors leading to the positive outlook of the patients described include their available positive role models and their spirituality. It must be stated that psychological health and spiritual well-being are integrated and related states. In addition, the traumatic event itself could aid in improving a patient’s outlook on life. Many mental health practitioners are learning that loss will often build strength of character. There are numerous studies that demonstrate how people believe they benefit from extremely difficult life experiences (McMillcn et at, 1997, 1999). High rates of benefit after adversity were found among cancer survivors (Curbow et al, 1993) despite the negative effects of treatment. Benefits of adversity to trauma patients include changed life priorities, increased sense of self-efficacy, enhanced sensitivity to others, improved personal relationships, and increased spirituality.

However, maxillofacial patients will not see the benefits of adversity until they are able to attach a meaning to the adverse event. Once a patient is able to apply a meaning to the life-threatening traumatic event, the introduction of benefit- related concepts can be attempted and discussed. This is a technique used in psychotherapy called *refmminj*?, where an event is relabeled to search for the positive aspects in relation to the patient’s strengths and abilities to face serious problems. If this can be achieved, the patient can begin to be urged to think about ways that they have benefited, making the traumatic event seem more palatable and easier to think about and cognitively process. Positive outcomes of prosthetic treatment would be anticipated at this point because patients have stopped seeing themselves as victims and, instead, as capable human beings. The patients interviewed were able to find meaning in their traumatic losses, eidier through their developmental history or through their own spirituality.

Patients do not want an insulated attitude of caregiving developed from treatment outcomes that may fall short of the intended result or an indifferent attitude created by the frequent loss of patients to death. These attitudes will result in stunted improvement by the patient. Rather, patients want health care providers who exhibit empathy and who can present genuine emotions. In addition, prosthodontists who can learn to actively listen to patients, communicating to them an understanding of their feelings and desires for their treatment plans, will aid in positive results in the management of their patients.

References

Averill J. Grief: Its nature and significance. In: Carr A, et al (eds). Grief: Selected Readings. New York: Health Sciences Publishing Corp, 1975:232.

Chandra P, Chaturvedi S, Channabasavanna S, Anantha A, Reddy B, Sharma R. Psychological well-being among cancer patients receiving radiation: A prospective study. Qual Life Res 1998;7:495.

Curbow B, Sommerfield M, Baker F, Wingard J, Lcgro M. Personal changes, dispositional optimism, and psychological adjustment to bone marrow transplantation. J Behav Med 1993;16:423.

Gillis R. Psychological implications of patient care. In: Lanev W (ed). Maxillofacial Prosthetics. Littleton, MA: PSG Publishing Co, 1979: Chapter 2.

Guyatt G, Feeny D, Patrick D. Measuring health-related quality of life. Ann Intern Med 1993; 118:622.

House M. Full denture technique. In: Classic Prostho- dontic Articles, vol. 3. Chicago: American College of Prosthodontists, 1978: Chapter 1.

Lanev W, Gibilisco J. Management of craniofacial pain. In: Diagnosis and Treatment in Prosthodontics. Philadelphia: Lea & Fcbiger, 1983: Chapter 6.

McMillcn J. Better for it: How people benefit from adversity-'. Soc Work 1999;44(5):455.

McMillen J, Smith E, Fisher R. Perceived benefit and mental health after three types of disaster. J Consult Clin Psychol 1997;65:733.

Peretz D. Development, object-relationships, and loss. In: Schoenberg P>, et al (eds). Loss and Grief: Psychological Management in Medical Practice. New York: Columbia University Press, 1970:3-19.

Reimbursement Considerations for the Maxillofacial Prosthetic Practice

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Maxillofacial prosthetic services should be a covered benefit under medical policies if the patient has medical insurance. The most common types of patients requiring maxillofacial prosthetic services are patients with congenital defects (eg, cleft palates), acquired defects, compromised function (eg, caused by cancer or stroke), and severe trauma (eg, the result of automobile accidents or gun shot wounds). It is imperative that patients' medical providers and insurance companies understand the medical necessity of prosthetic treatment so that patients can receive their rightful medical insurance benefits. A patient can then be rehabilitated to the optimal level and become a productive member of society. However, insurance coverage is often incorrectly denied due to the lack of education and understanding by all parties.

This chapter provides information on the basic types of insurance coverages and explains methods to obtain insurance reimbursement so that cost-effective treatment can be optimally provided. In most practices a small percentage of patients require maxillofacial prosthetic services. Moreover, if providers are not paid fairly or in a timely manner, they will likely redirect their practices to more traditional prosthetic services such as fixed, removable, and implant prosthetics. This results in decreased access or unavailability of maxillofacial prosthetic rehabilitation services. It also results in increased patient suffering and increased insurance costs to third-party carriers and government agencies that provide medical benefits under programs such as Medicare and Medicaid. The loss of access to maxillofacial prosthetic services will reduce the patient's ability to return to society in a functional and acceptable condition.

Resource-Based Relative Value System

In recent years there has been a shift in methods used to determine levels of reimbursement away from a fee-based system to the resource-based relative value scales (RBRVS) system. The RBRVS system attempts to compare and quantify different services in different specialties in an attempt to better equalize reimbursement levels across all specialties. There are three components used to determine these values. The first is the physician work component. To arrive at the work relative value unit (RVU), time spent with the patient, intensity of the work, and risk and difficulty of the procedure are factors that are considered. The other two components are practice expense (PE) and malpractice expense (ME). The reimbursement level is determined by adding these three value units together and applying a conversion factor (CF):

Reimbursements = total RVU X CF

The conversion factor may vary from medical insurance company to medical insurance company by region or state depending upon premiums paid and level of reimbursement determined by that insurance carrier. Unfortunately, the PF. values for maxillofacial prosthetics are very high (approximately 65% to 70% in a number of studies) in comparison to other medical specialties. This high PFi is still not fully appreciated or reflected in values used by the Health Care Financing Administration (HCFA), the oversight agency for Medicare, and other insurance carriers. The American Academy of Maxillofacial Prosthetics (AAMP), in collaboration with HCFA and the American Medical Association (AMA), was instrumental in developing the work RVUs for maxillofacial prosthetic services; these values have been published in the Federal Register. HCFA and the AMA lead the country in developing policy in this area and other insurance companies frequently follow their general guidelines as to payable benefits for maxillofacial services.

When submitting claims for medical insurance reimbursement for maxillofacial prosthetic services it is critical that the correct diagnosis codes and procedure codes be used. Errors or missing codes will result in rejection of claims. Maxillofacial prosthetic services codes are listed in the *Physician's Current Procedural 'Terminology* (CPT)* manual, codes 21076 to 21089, published by the AMA and updated yearly (Fig 2-1). Codes 21076 through 21087 have RVU values; codes 21088 and 21089 do not have RVU values but are evaluated on an individual basis. It is important to keep current copies of the CPT manual in the prosthodontic office for reference.

'l'he other section of codes that is often used by the maxillofacial prosthodontist are evaluation and management codes (E&M), also listed in the CPT manual. E&M codes are based not only on time but also risk of treatment (Fig 2-2). For example, management of an osteoradionecrosis (ORN) area in the mandible versus a routine follow-up visit would allow a higher level of coverage due to the risk of complications involved, even for the same time spent with the patient.

To submit a claim using CPT codes requires a corresponding and supportive diagnostic code from the *International Classification of Disease*, 9th revision (ICD 9), which lists different diseases, injuries, and defects. It is imperative that one keeps accurate medical records with individual medical histories, evaluations, procedures completed, diagnoses, risks, and time spent when using E&M codes. As a rule of thumb, if it is not documented you did not do it. There are various types of medical conditions that medical insurance will provide insurance coverage for utilizing CPT codes or E&M codes. It is important to realize the range of medical problems and treatments that can be submitted for coverage. For example, medical insurance coverage may be obtained not only for replacing missing body parts such as in a maxillectomy patient, but also for altered anatomy such as a cleft palate or severe traumatic injuries. Altered function such as velopharyngeal incompetence due to soft palate dysfunction secondary to a stroke should also be a covered service. Treatment of other types of dysfunction and complications such as xerostomia, osteoradionecrosis, and infections secondary to chemotherapy are covered procedures under E&M codes. It is important to be very familiar with both the CPT manual and ICD 9 diagnostic codes so that claims are properly submitted and not rejected due to improper completion of the claim form.

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Head

Skull, facial bones and temporomandibular joint,

Incision

(For drainage of superficial abscess and hematoma, see 20000)

(For removal of embedded foreign body from dentoalveolar structure, see 41805, 41806)

21010 Arthrotomy, temporomandibular joint

(21011 has been deleted. To report, use 21010 with modifier -50 or 09950)

Excision

(For biopsy, see 20220, 20240)

21015 Radical resection of tumor (eg, malignant neoplasm), soft tissue of face or scalp

(21020 has been deleted. To report, use 61501)

21025 Excision of bone (eg, for osteomyelitis or bone abscess); mandible

21026 facial bone(s)

21029 Removal by contouring of benign tumor of facial bone (eg, fibrous dysplasia)

21030 Excision of benign tumor or cyst of facial bone other than mandible

21031 Excision of torus mandibularis

21032 Excision of maxillary torus palatinus

21034 Excision of malignant tumor of facial bone other than mandible

21040 Excision of benign cyst or tumor of mandible; simple

21041 complex

21044 Excision of malignant tumor of mandible;

21045 radical resection

(For bone graft, see 21215)

21050 Condylectomy, temporomandibular joint (separate procedure)

(21051 has been deleted. To report, use 21050 with modifier -50 or 09950)

21060 Meniscectomy, partial or complete, temporomandibular joint (separate procedure)

(21061 has been deleted. To report, use 21060 with modifier -50 or 09950)

21070 Coronoidectomy (separate procedure)

(21071 has been deleted. To report, use 21070 with modifier -50 or 09950)

Introduction or Removal

(For application or removal of caliper or tongs, see 20660, 20665.) Codes 21076-21089 describe professional services for the rehabilitation of patients with oral, facial or other anatomical deficiencies by means of prostheses such as an artificial eye, ear, or nose or intraoral obturator to close a cleft. Codes 21076-21089 should only be used when the physician actually designs and prepares the prosthesis (ie, not prepared by an outside laboratory).

21076 Impression and custom preparation, surgical obturator prosthesis

21077 orbital prosthesis

21079 interim obturator prosthesis

21080 definitive obturator prosthesis

21081 mandibular resection prosthesis

21082 palatal augmentation prosthesis

21083 palatal lift prosthesis

21084 speech aid prosthesis

21085 oral surgical splint

21086 auricular prosthesis

21087 nasal prosthesis

21088 facial prosthesis

21089 miscellaneous

Fig 2-1 Maxillofacial prosthetic service codes. *Physicians' Current Procedural Terminology* (CPT) manual, 1999. (Reprinted with permission from the American Medical Association, Chicago, IL.)

Evaluation and Management

Office or Other Outpatient Services

The following codes are used to report evaluation and management services provided in the physician's office or in an outpatient or other ambulatory facility'. A patient is considered an outpatient until inpatient admission to a health care facility' occurs.

To report services provided to a patient who is admitted to a hospital or nursing facility in the course of an encounter in the office or other ambulatory facility, see the notes for initial hospital inpatient care (page 12) or comprehensive nursing facility assessments (page 23).

For services provided by physicians in the Emergency Department, see 99281-99285.

For observation care, see 99217-99220.

For observation or inpatient care services (including admission and discharge services), see 99234-99236.

New Patient

99201 Office or other outpatient visit for the evaluation and management of a new patient, which requires these three key components:

- **a problem focused history;**
- **a problem focused examination; and**
- **straightforward medical decision making.**

Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs.

Usually, the presenting problems are self limited or minor. Physicians typically spend 10 minutes face-to-face with the patient and/or family.

Office or other outpatient visit for the evaluation and management of a new patient, which requires these three key components:

- **an expanded problem focused history;**
- **an expanded problem focused examination; and**
- **straightforward medical decision making.**

Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs.

Usually, the presenting problem(s) are of low to moderate severity. Physicians typically spend 20 minutes face-to-face with the patient and/or family.

99203 **Office or other outpatient visit** for the evaluation and management of a new patient, which requires these three key components:

- **a detailed history;**
- **a detailed examination; and**
- **medical decision making of low complexity.**

Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs.

Usually, the presenting problem(s) are of moderate severity. Physicians typically spend 30 minutes face-to-face with the patient and/or family.

99204 **Office or other outpatient visit** for the evaluation and management of a new patient, which requires these three key components:

- **a comprehensive history;**
- **a comprehensive examination; and**
- **medical decision making of moderate complexity.**

Counseling and/or coordination of care with other providers or agencies are provided consistent with the nature of the problem(s) and the patient's and/or family's needs.

Fig 2-2 Evaluation and management codes, *Physicians'Current Procedural Terminology* (CPT) manual, 1999. (Reprinted with permission from the American Medical Association, Chicago, IL.)

Types of Insurance Coverage

Every medical insurance policy has slightly different types of coverage and it is impossible to address all of the possibilities. Because Medicare is probably the most complex and also the most influential type of general medical policy in the US, it will be addressed first.

Medicare

Medicare is a federal government program directed by HCFA providing medical coverage for people 65 years and older and for some persons with disabilities, through the Supplementary Security Income (SSI) program. HCFA oversees Medicare and sets national guidelines of coverage but subcontracts (usually to the lowest bidder) to individual insurance carriers by region and state for the actual day-to-day administration. These carriers may change from time to time as contracts come up for bid and renewal. Due to political realities and pressures, Congress has promised to provide medical coverage for senior citizens but has not adequately funded the program. Rather than cutting services and benefits, which would be politically unpopular, they have directed HCFA to reduce reimbursement levels and created budget neutrality' from year to year so that increased costs are not encountered. The result is progressively lower reimbursement levels from Medicare each year. The new rates are published yearly in late November or early December.

Providers must make a choice when considering treating patients with Medicare coverage: treat Medicare patients and abide by the limiting charge guidelines or not treat these patients at all. It is against federal law to treat a Medicare patient and have him or her pay the difference up to your usual and customary fees. If one wants to be paid by Medicare or obtain reimbursement for Medicare patients, one has to enroll in Medicare as a provider. There are two types of Medicare providers. A *participating provider* with Medicare agrees to accept all Medicare payments at the participating provider fee level. Medicare will issue the check directly to the provider for reimbursement. The patient is responsible for a yearly deductible and copayment (usually 20%). After the patient pays a yearly deductible, Medicare (HCFA) reimburses at 80% of the covered allowable charge. The patient is responsible for the remaining 20%. One cannot request a pretreatment estimate (PTE) of payment from Medicare. The payment received is based upon published limiting charges in Medicare publications. A *nonparticipating provider* charges the patient 115% over what the participating provider will charge but must collect payment directly from the patient. The payments will go to the patient and not the provider of care. It is best to collect the total fee from the patient, then the patient will be reimbursed by Medicare for the treatment costs. The patient will be reimbursed at a 5% lower level because the provider does not participate. A nonparticipating provider can decide on a casc-bv- case basis whether to accept assignment on a particular claim. Nonparticipating providers are paid at a slightly lower level, 5% “on an assigned claim,” than participating providers in the Medicare program. In this situation the check will come to the provider. Providers may change status with Medicare yearly. Providers are committed to that status until the next year’s renewal date.

Limiting charge levels, both participating and nonparticipating, are published by Medicare carriers under HCFA guidelines in November or December, which then go into effect January 1. The reimbursement levels are determined by the RVUs and Medicare conversion factors, which are determined by Medicare taking into account Medicare’s budget, budget neutrality issues, and political pressure to reduce costs. Reimbursement levels vary somewhat from region to region due to geographical practice cost indexes (GPCS), which to a degree account for different practice expense costs that vary by region and from cities to rural areas. Providers in private practice have the choice of how to enroll; those in hospitals or other institutional settings, such as dental schools or medical schools, may be forced to comply with institutional policy.

Prosthodontists are not allowed to file under durable medical equipment (DME) HCPCS codes, as these arc prosthetic codes for nonphvsi- cians. Dentists are considered physicians and are not allowed to bill in this area. If your local insurance company tries to place your claims in this area, it is clearly an error and they will need to be contacted to have it corrected.

CPT codes 21076 to 21088 contain limiting charges and global periods. The global period means that all appointments and procedures during that period arc included in the one fee that relates to that specific procedure. The global period for an immediate obturator (21076) is 10 days. The rest of the maxillofacial prosthetic CPT codes have global periods of 90 days. One can submit additional charges for unrelated procedures, but the provider will need to use a modifier on the claim form (discussed later in this chapter) for that patient during the global period if it is unrelated to original CPT codes. An example would be treating osteoradionecrosis for a patient with an obturator. This treatment could be billed under E&M codes since it would be unrelated to the original CPT prosthetic code. If two distinct and separate maxillofacial prosthetic procedures are performed during a global period, a modifier (code 79) must be used to avoid a 50% reduction of reimbursement lor the second prosthesis.

Code 21089 is a miscellaneous code for maxillofacial prosthetic procedure services not described by the other 11 codes. There is no limiting charge on this code, and one can charge the usual and customary fee. Local medical carriers have shown a wide range of payments and interpretation of coverage for this code. One will need to send additional documentation and explanations to obtain coverage for this CPT code. This code cannot be denied as a noncovered service, but the amount paid by local carriers can vary. You may need to negotiate levels of coverage and procedures covered.

HCFA Claim Form 1500

It is critical that the correct form be used and that the form be accurately completed to HCFA guidelines. These forms are computer scanned, and if they are not correctly completed they will be rejected. These guidelines are also in a constant state of flux and may vary somewhat with local carriers. The standard form is the HCFA 1500 (Fig 2-3). These forms can be purchased from die American Medical Association. The forms are prepared with a special red ink so a photocopy will be rejected. The claim form must not be bent or folded and it must be typed in black ink.

When one enrolls in Medicare as either a participating provider or non participating provider, one will receive two or three identifying numbers, a UPIN, a provider number, and a group practice number. The UPIN is placed in Box 17a and is used primarily for a “referring” physician or dentist. The UPIN is necessary when you arc referring a patient for consultation or when you are not sure that you are going to be able to treat the patient. Additionally, when you order, take, and read radiographs in your own office you are essentially referring diagnostic radiographs to yourself. The radiographs are not purchased outside the office, and the limiting charge fee is inclusive for taking and reading radiographs which you properly identify using the UPIN, simultaneously with the XA modifier, to be discussed later in this chapter. Second, you are given a provider number to be used in Block K for each line of service placed on the HCFA 1500. This is to identify that you performed each service. Finally, you are given a group practice number, also known as a provider number, to be placed in Block 33 if you have more than one doctor in your practice. If you are a sole practitioner you will still have to place your provider number in Block IC as well as Block 33. They are both necessary, and they may be different from each other. You must link the ICD 9 codes and the CPT codes so that reimbursement can be determined. The claim will be returned if these codes are not related and you will have to recode the claim in a correct manner and resubmit it. Remember, dentists have the same privileges as physicians when billing Medicare.

When doing appropriate coding on the HCFA Form 1500 it is not always possible to write an exact description of the procedure provided to the patient without the use of modifiers. Modifiers are used to more precisely explain what service or procedure was provided. The following is a list of some common modifiers that could be used on a claim. Radiology codes require the use of the modifier XA, which means the radiograph was taken and read in the office by the provider and was not a “purchased test,” in which the patient was sent out for the radiograph.

- Modifier 22—Use when the procedure is of greater difficulty than usually required for the CPT code chosen.
- Modifier 52—Use when the procedure is a reduced form of the usual procedure of the CPT code chosen.
- Modifier 24—Use when performing an unrelated evaluation and management (E&M) procedure then another procedure on the same day. The E&M procedure cannot be linked to the maxillofacial prosthesis at all. This includes the day before and the day after the procedure.
- Modifier 25—Use when performing a totally separate identifiable E&M procedure then another procedure on the same day. If, too, cannot be linked to the maxillofacial prosthesis at all. This includes the day before and the day after the procedure.
- Modifier 79—Use when performing an unrelated procedure during the global period of a maxillofacial prosthesis or to explain a second prosthesis. Medicare now publishes a Medicare B Office Guide through the National Heritage Insurance Company, Provider Services.

Denial of Medicare claims

If a Medicare claim is denied, first look over the claim very carefully to make sure all of the information is in correct format, the appropriate boxes are filled in, and the claims are submitted on the correct red form. Even minor errors can result in denials. If the denial states that treatment was not a covered service in codes 21076 through 21087, or if they reduce the reimbursement levels from those published in the November/December HCFA guidelines, the carrier is in error. HCFA determines reimbursement levels on a national basis and local carriers cannot legally reduce these levels. Unfortunately, this error still happens quite often from lack of knowledge or understanding on the part of an individual carrier. This error is partly due to the very low volume of maxillofacial HCFA claims received by each carrier. Be sure to not submit under the HCPCS codes and DME codes as this is incorrect for maxillofacial prosthetic professional services. If the carrier insists that maxillofacial prosthetic procedures need to be submitted under FICPCS and DME codes, the carrier is not following national guidelines since maxillofacial prosthodontists are not allowed to submit under these areas of codes. If a 21089 and other procedures are denied, you have to follow HCFA guidelines to correct these mistakes.

If everything is correct and was completed as described above but the claim is still denied, specific procedures need to be followed. The first step to correct a denial is to file an appeal in writing. Unfortunately, this rarely results in correction of the problem and will usually end with a form letter stating, “We made a new and independent review of your claim. The person doing the review did not take part in making the first decision.” Or, “This is in regards to a review request for service(s) on (date). Our medical staff has reviewed the submitted documentation and have determined that no payment can be allowed for the Prepare Face/Oral Prosthesis, code 21076 through code 21089, because this service is not covered by Medicare Part B.” It is rare for any Medicare carrier to have adequately trained personnel in maxillofacial prosthetics. You must first appeal in writing, however, before you proceed to the next level of appeal, a Fair Hearing.

At a Fair Hearing, the claim is reviewed in “independent reviews” by a person paid by Medicare. You can request that Fair Hearings be done by telephone or in person at a location convenient to you. In most cases, Medicare personnel people performing these reviews are well trained, reasonable, and will consider your position and argument seriously, often reversing earlier decisions. On denied cases it can also be advantageous to have the patient present at an in-person hearing to demonstrate the need for the maxillofacial prosthesis. For example, if an obturator has been denied, ask the patient to remove the obturator and try to speak. This has been done on a number of occasions and the claim is usually approved. If the Fair Hearing does not result in coverage on a clearly covered procedure, the next step is to obtain legal help and go before an administrative law judge in

PLEASE
DO NOT
STAPLE
IN THIS
AREA

[redacted]

[redacted]

a:
cc

HEALTH INSURANCE CLAIM FORM

i MEDICARE MEDICAID CHAMPUS CHAMPVA GROUP FECA OTHER HEALTH PLAN BLK LUNG *(Medicare#}* t j *(Medicaid* **ft)** I j *(Sponsor's* SS/V) j j *(VA Fite #)* 1 j *(SSN or ID;* P j *(SSN}* j | *(ID)*		1a INSURED'S i.D. NUMBER (FOR PROGRAM IN ITEM 1) 1 23 4 56789A ________________________
2. PATIENT'S NAME (Last Name. First Name. Middle Initial) P A T T R N T	3. PATIENT'S BIRTH DATE CCY MM ■ DD YY S=X 01·02 1900!* FH	4. INSURED S NAME (Last Name. First Name, Middle Initial)
5 PATIENT'S ADDRESS (No.. Street) 1 ANYWHERE ST APT 1	8 PATIENT RELATIONSHIP TO INSURED SeH P] Spouse □ Child fj 0lhcr Lj	7 INSURED S AOORESS (No.. Street)
CITY STATE	8 PATIENT STATUS Single • i Married i_____ | Other j	CITY j STATE
ZiP CODE 04103 — TELEPFtONE - Include Area Cede) (207) 555-1 321	Employed |—j Full-Time .—Pan-Time.-'—-	ZIP CODE i TELEPHONE (INCLUDE AREA CODE! i()
9. OTHER tNSURED'S NAME (Last Name. First Name. Middle Initial)	10. IS PATIENT'S CONDITION RELATED TO:	! 1 INSURED S POulCY GROUP OR FECA NUMBER NONE
3. OTHER INSUREO S POLICY OR GROUP NUMBER 89XV123 BC/BS/ME	3. EMPLOYMENT? (CURRENT OR PREVIOUS) DN0	a INSURED'S DATE OF BIRTH SEX MM DO YY OC "□ FD
O OTHER INSURED S DATE OF BIRTH SEX MM DO YY Mfr e n	b. AUTO ACCIDENT? PLACE (State) n^s □NO , ,	b EMPLOYER'S NAME OR SCHOOL NAME
c EMPLOYER'S NAME OR SCHOOL NAME	c. OTHER ACCIDENT? □VES O0	C. INSURANCE PLAN NAME OR PROGRAM NAME
d. INSURANCE PLAN NAME OR PROGRAM NAME BC/BS/ME	iCd. RESERVED FOR LOCAL USE ATTACHMENT	d. IS THERE ANOTHER HEALTH BENEFIT PLAN? ; i T£S i X NO // yes. return lo and complete item 9 a-d.

READ 8ACK OF FORM 8EF0RE COMPLETING & SIGNING THIS FORM.

12. **PATIENT'S OR AUTHORIZED PERSON'S SIGNATURE I authorize the release** *of* **any medical or oiher ir-formaticc necessary ■o process Inis claim. I also request payment of government benefits either to myself or to the party vvho accepts assignment below.**

SIGNEO. 01/01/00

!3 INSURED'S OR AUTHORIZED PERSON'S SIGNATURE 5 authorize **payment of medical benefits to the undersigned physician or supplier for services described beiew**

!4 DATE OF CURRENT *J* ILLNESS (First symptom) OR MM : DD : YY *M* INJURY (Accident) OR 1 PREGNANCY(LMP)	**15. iF PATIENT HAS HAD SAME OR SIMILAR ILLNESS. GtVE FIRST DATE MM I DO YY**	**16 DATES PATIENT UNA8LE TO WORK IN CURRENT OCCUPATION MM DO : YY FROM ; MM OD : YY TO**
I ? NAME OF REFERRING PHYSICIAN OR OTHER SOURCE	**17a 1.0. NUMBER OF REFERRING PHYSICIAN**	**I. HOSPITALIZATION DATrS RELATED TO CURRENT SERVICES MM . DD ; YY MM DD ; YY**
ID R6SERVEO FOR LOCAL USE		**20. OUTSIDE LAB? S CHARGES C ,YE-S NO j**
21. DIAGNOSIS OR NATURE OF ILLNESS OR INJURY. (RELATE ITEMS 1.2.3 OR 4 TO ITEM 24E BY LINE) ---------------------- ; **, , 1 4 1 . 0 , 9 0 9 . 2 * g i 5 2 7 . 7 4 90.9.3.**		***22* MEDICAIO RESUBMISS50N CODE | ORIGINAL REF NO.** **23. PRIOR AUTHORIZATION NUMBER**

'2C. A		**8**	**C**	**O**	**E**	**F**	**G**	**H**	**1**	**J**	**K**
. DATE'S) OF SERVICE - From To MM DO YY MM OD YY		**Place of Servic e**	**Type of Service**	**PROCEDURES. SERVICES. OR SUPPLIES (Explain Unusuai Circumstances) CPT.'HCPCS I MODIFIER**	**OtAGNOSiS CODE**	**sCHARGES**	**DAYS' OR UNITS**	**Ei'SSY Family Plan'**	**EMG**	**COS**	**RESERVED FOR LOCAL USE**
01 01 00	**01 01 00**	**11**		**99205.125..**	**. 5 2 7 , 7**	**1 1 3 0 8**	**0 1 0**				**M X X 2 2 0**
0 1 0 1 0 0	**0 1 0 1 0 0**			**7 0 3 5 5 1 X A ....**	**5 2 7 . 7**	**3 2 1 4**	**D 1 0**				**M X X 2 2 0**
0 1 0 1 Q O	**0 1 0 1 0 0**	**1 1**		**2 1 0 7 6 i 7 9 _ _ _ _ _ _ _**	**1 4 1 . 0**	**1 3 0 0 i 0 0**	**P1.0**				**M X X 2 2 0**
				**i **							
				i i			**_ _ _**				
				_ _ _ _ _ _ _ _ L J „	**. . . . J**						

2S FEDERAL TAX - D NUMBER SSN £:N • 26 PATIENT'S ACCOUNT NO 2? ACCEPT ASSIGNMENT'-* _(For oovt claims. see back) □ □ i ____ □ y£S K S N 0	**28. TOTAL CHARGE 29 AMOUNT PAID** *** 1 4 4 5 2 2 s 1 4 4 5 2 2**	**30- BALANCE DUE** **J 0 0 0 0**
3!, SIGNATURE OF PHYSICIAN OR SUPPLIER ; 32 NAME AND ADDRESS OF FACILITY WHERE SERVICES WERE INCLUDING DEGREES OR CREDENTIALS j RENDERED (It otner than home or etfice} fi certify lhat the statements on the averse apply to this bill and are made a part thereof.) **0 1 / 0 1 / 0 0 SAME** **SISNEO DATE**	**33 PHYSICIAN'S SUPPLIER'S 3ILLING NAME. ADDRESS. ZIP CODE & PHONE *ft*** **D R . J O H N Q . PROSTHODONTIST** **25 DENTURE WAY** **ANYWHERE, ME 041 03 p p „ 4 4 r** **PIN# i GRP# ir KZ Z O**	

{APPROVED 3Y AMA COUNCIL ON MEDICAL SERVICE fl/86} *PLEASE PRINT OR TYPE* **APPROVED OM0-O938-OOO8 FORM HCFA-1500 (12-90), FORM RR3-1S00. APPROVED 0M8-1215-0055 FORM OW'CP-1500. APPROVED OMB-0720-0001 (CHAMPUS}**

Fig 2-3a Health Care Financing Administration (HCFA) Form 1500.

Follow instructions exactly; any errors or missing information will result in rejection of the claim.

1. Type "X" in the Medicare box.
la. Type all 9 digits consecutively with no breaks or dashes, including the letter at the end of or preceding the number.
2. Last name, first, middle initial, all caps, no titles or punctuation; use of a space or a comma between names is permitted.
3. Must use eight-digit format for this date. (Everywhere else use six-digit format for dates.) Be sure the "X" is in the box, not up over it or off to the side.
4. N/A
5. All caps, address with no punctuation necessary.
6. N/A
7. N/A
8. N/A
9. If MSP (Medicare Secondary Payer), Insured's name here.
9a. Secondary insurance ID number here.
9b. N/A
9c. N/A
9d. Insurance plan here.
10a. Type "X" in the appropriate box.
10b. Type “X" in the appropriate box.
10c. Type "X" in the appropriate box. lOd. Type "ATTACHMENT" when sending information with a claim.
11. Type "NONE" if the patient does not have other primary insurance. If this is not done, the claim form will be automatically rejected. If Medicare is secondary, you must bill the primary insurance first and then bill Medicare for copay, and 11a, 11 b, He, and 1 Id will have to be completed.
11a. N/A
lib. N/A
11c. N/A
lid. Type "X" in the NO box, as no other insurance refers to other primary insurance. You must make a good faith effort to determine whether Medicare is the primary insurance carrier or not.
12. Have the patient sign and date this field.
13. Leave blank, unless you are "accepting assignment" on this particular claim, as you would if state welfare was the secondary payer.
14. Six-digit date if this was an accident only.
15. N/A
16. N/A
17. Referring provider's name here.
17a. UPIN number of referring physician here. If you are doing your own x-rays you need to put your UPIN number here and name on 17.
18. N/A
19. N/A
20. Place an "X" in the NO box.
21. Primary diagnosis in 1, with subsequent helpful diagnoses in the other fields; use ICD 9 code to indicate primary diagnosis. Each code must be as specific as possible. Also add diagnosis and condition codes that may help to clarify and support this claim submission but never enter more than four codes on any one claim. Make sure to check the number of digits necessary for a code.
22. N/A
23. N/A—Medicare will not preauthorize any treatment.
24A. Six-digit date of service (always).
24B. Place of service: Office = 11, Inpatient Hospital = 21, Nursing Facility = 32.
24C. N/A in Maine. If applicable in your state, then 1 =med- ical, 2=surgical or maxillofacial prosthesis, 4=radi- ographs, 9=other medical. Check with your local provider service representative.
24D. CPT code and modifier if applicable.
24E. ICD 9 diagnosis codes.
24F. No dollar signs, no decimals or spaces before cents.
24G. Maine requires you use "010" in this field pertaining to one unit of service.
24H. N/A
241. N/A
24J. N/A
24K. "Servicing Provider" ID number here (if multiple doctors in a private practice).
25. Your TIN (tax identification number) number here for secondary insurance company's use.
26. N/A
27. Place ”X" in the appropriate box. If you participate you must check YES; if nonparticipant, you can choose on any claim whether you want money to come to you or go to insured by accepting or not accepting assignment.
28. No dollar signs, no decimal or spaces before the cents.
29. Same as 28.
30. Same as 27 and 28.
31. Doctor signs here; type the six-digit date of submission.
32. Type "SAME" if done in the office; if place of service is a hospital or a nursing facility, you will need to type that name and address.
33. Your name and address typed or stamped. This is where you type your provider identification number in the lower right corner of this field.

Fig 2-3b Instructions for completing the Health Care Financing Administration (HCFA) Form 1500.

court. Incorrect denials, though, arc usually reversed in Fair Hearings. In either case, it is important to have very accurate documentation and records to support your claim. Citing past cases where the same procedures were covered is a very strong argument in your favor.

It is important to thoroughly understand these appeal procedures and have your office set up to pursue and correct these errors. Since specific codes and RVU values have been developed by the AAMP, in conjunction with the AMA and HCFA, these problems have been reduced but unfortunately still do occur. The 21089 codes can be particularly difficult and coverage can vary widely from carrier to carrier. It can be helpful to get the patient involved in these denials, especially if this person has political contacts. Medicare and HCFA respond very quickly to congressional inquiries from Washington, DC, and a slow bureaucracy can be made to move much more quickly.

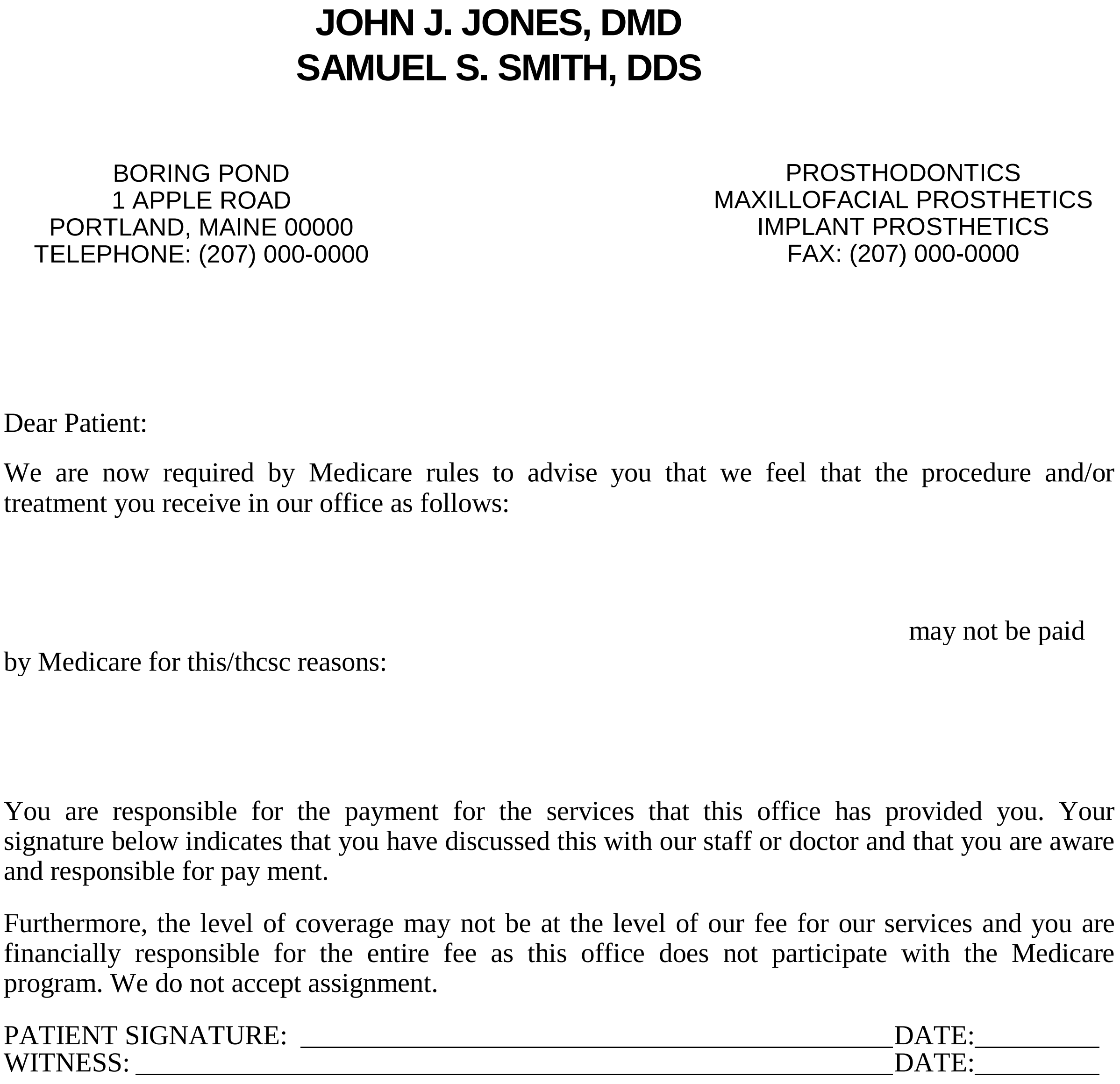
If you treat a Medicare patient and you suspect or know a procedure is not covered by Medicare, you can still treat that patient but you must inform the patient that it is probably not a covered procedure. The patient signs a waiver of liability form for services that you know are not covered and agrees to be financially responsible for the treatment rendered (Fig 2-4). The waiver is not necessary if the procedures are clearly not covered under Medicare guidelines, only for services you feel are ambiguous as to coverage. For example, dental restorations are clearly not covered, so no waiver of liability' for this treatment is needed. The patient should also sign a consent form to obtain medical information from other physicians, hospitals, or private practices to substantiate medical necessity (Fig 2-5). If you do not accept assignment on a claim so that you are a nonparticipating provider and you still wish to help a patient with denial of claims appeals and Fair Hearings, you will need signed consent to allow you to intervene (Fig 2-6).

Medicare and managed care

Congress and HCFA promote Medicare managed care plans. HCFA has contracted with individual medical carriers in different areas of the country to offer this managed care coverage. They pay carriers a set amount of reimbursement for each member to provide all the treatment that the patient needs. Carriers must follow HCFA guidelines as to medically necessary treatments. Maxillofacial prosthetic services arc determined to be medically necessary services by HCFA and this care must be provided. The managed care insurance companies try to reduce costs and increase profits by negotiating contracts with providers at a reduced rate. The managed care carrier is not restricted by Medicare fee guidelines and can negotiate either higher or lower reimbursement levels. Coverage is restricted by treatment guidelines. If the Medicare managed care carrier has a provider in the network with whom they have negotiated a contract, they can require the patient to go to that provider. If they do not have a provider in the network, such as a maxillofacial prosthodontist, they still must provide this medically necessary treatment per HCFA guidelines. A provider can then negotiate with that company at either a higher or lower reimbursement level than Medicare allows. If an acceptable payment level cannot be agreed to and they do not have a provider in their network, you may agree to treat the patient and the carrier must pay what Medicare reimbursement (limiting charges) would be in your area for that care. If they deny care that is clearly covered, HCFA is very interested in hearing about these infractions. The patient must follow an appeal process outlined by HCFA with any managed care carrier. These managed care contracts are still relatively new and are in a state of flux. Some carriers after contracting with Medicare for a year or two withdraw from the program due to inadequate reimbursement levels by Medicare.

Unisys (Champus)

Unisys is a federal medical insurance program for the military, usually active-duty personnel and dependents, although.some other people may be included in this grouping as well. Unisys is required to follow HCFA guidelines as to coverage and reimbursement levels. Unfortunately, it seems that administrators in this program frequently have



JOHN J. JONES, DMD
SAMUEL S. SMITH, DDS

BORING POND
1 APPLE ROAD
PORTLAND, MAINE 00000
TELEPHONE: (207) 000-0000

PROSTHODONTICS
MAXILLOFACIAL PROSTHETICS
IMPLANT PROSTHETICS
FAX: (207) 000-0000

Dear Patient:

We are now required by Medicare rules to advise you that we feel that the procedure and/or treatment you receive in our office as follows:

may not be paid

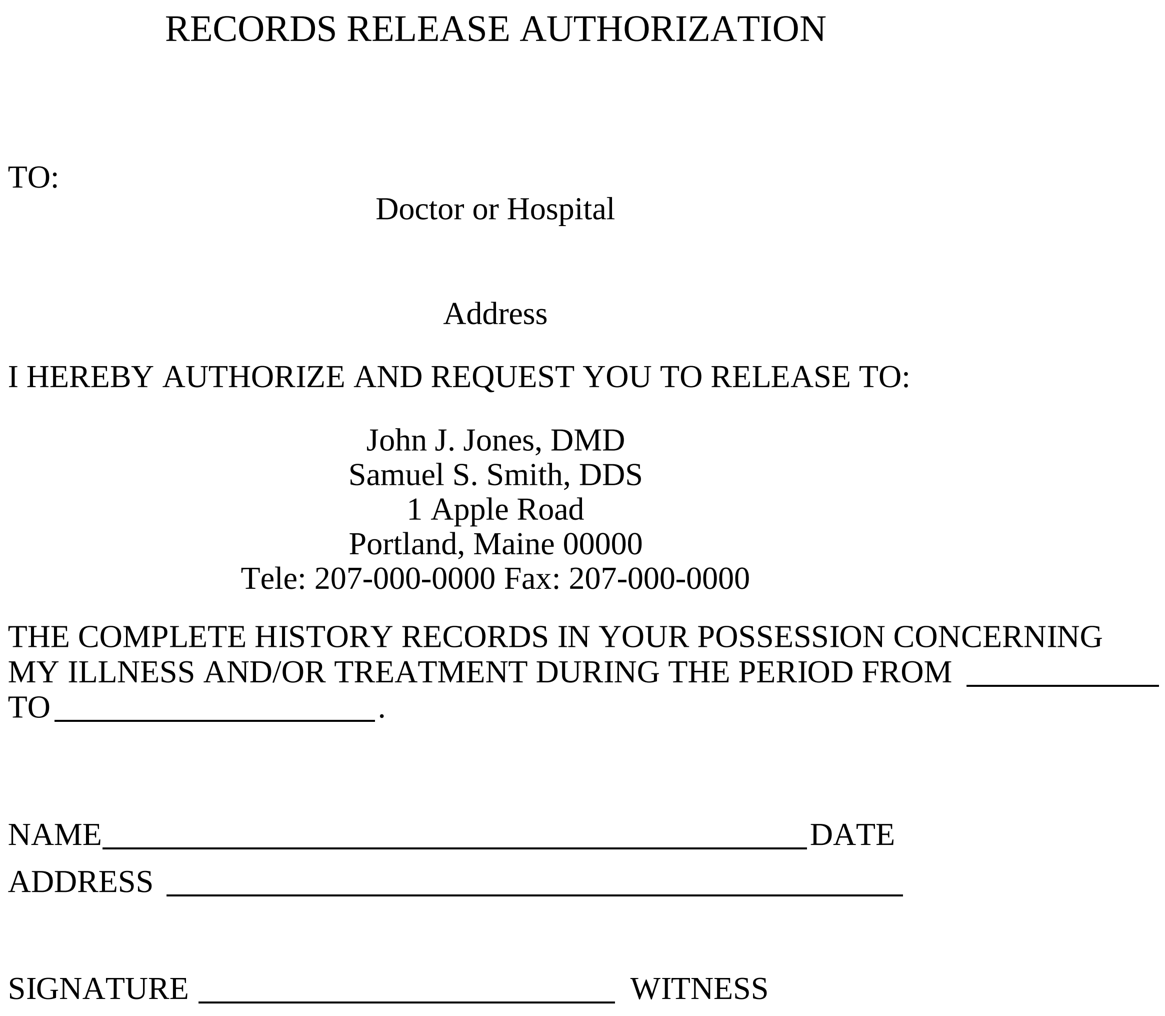
by Medicare for this/thcsc reasons:

You are responsible for the payment for the services that this office has provided you. Your signature below indicates that you have discussed this with our staff or doctor and that you are aware and responsible for pay ment.

Furthermore, the level of coverage may not be at the level of our fee for our services and you are financially responsible for the entire fee as this office does not participate with the Medicare program. We do not accept assignment.

PATIENT SIGNATURE: ____DATE:_________
WITNESS: ____DATE:_________

Fig 2-4 Waiver of liability form, National Heritage insurance Company-Medicare Carrier, State of Maine.



RECORDS RELEASE AUTHORIZATION

TO:
Doctor or Hospital

Address

I HEREBY AUTHORIZE AND REQUEST YOU TO RELEASE TO:

John J. Jones, DMD
Samuel S. Smith, DDS
1 Apple Road
Portland, Maine 00000
Tele: 207-000-0000 Fax: 207-000-0000

THE COMPLETE HISTORY RECORDS IN YOUR POSSESSION CONCERNING MY ILLNESS AND/OR TREATMENT DURING THE PERIOD FROM ____________ TO ____________________.

NAME____DATE

ADDRESS ____

SIGNATURE __________________________ WITNESS

Fig 2-5 Records release authorization form letter.

JOHN J. JONES, DMD
SAMUEL S. SMITH, DDS

BORING POND
1 APPLE ROAD
PORTLAND, MAINE 00000
TELEPHONE: (207) 000-0000

PROSTHODONTICS
MAXILLOFACIAL PROSTHETICS
IMPLANT PROSTHETICS
FAX: (207) 000-0000

ONE TIME PATIENT AUTHORIZATION FORM FOR USE BY PROVIDER

BENEFICIARY NAME

MEDICARE II) #

1 REQUEST THAT PAYMENT OF AUTHORIZED MEDICARE BENEFITS MAY BE MADE ON MY BEHALF TO DR. JOHN J. JONES OR DR. SAMUEL S. SMITH FOR ANY SERVICES FURNISHED TO ME BY THAT PROVIDER. I ALSO AUTHORIZE ANY HOLDER OI MEDICAL INFORMATION ABOUT ME NEEDED TO DETERMINE BENEFITS OR BENEFITS FOR RELATED SERVICES, BE RELEASED TO THE HEALTH CARE FINANCING ADMINISTRATION AND ITS AGENTS.

AND/OR

PHYSICIAN/SUPPLIER INQUIRY AUTHORIZATION (PRIVACY ACT FORM)

DUE TO MY NON-ASSIGNED CLAIM, ACCORDING TO MEDICARE RULES, I AUTHORIZE DR. JOHN J. JONES OR DR. SAMUEL S. SMITH TO ACT ON MY BEHALF TO DO ONE OR MORE OF THE FOLLOWING:

INQUIRE ON:
- STATUS OF CLAIM
- COPY OF EOMB
- COPY OF CHECK
- OTHER, EXPLAIN

- REQUEST REVIEW OF PAYMENT
- OR DENIAL
- REQUEST FAIR HEARING

-TELEPHONE
- ON-THE-RECORI)
- IN PERSON

A PHOTOCOPY OF THIS SIGNATURE ON FILE AND PRIVACY ACT FORM WILL BE VALID IN THE EVENT THE PROVIDER NEEDS TO SHOW PROOF FOR ANY OF THE ABOVE INFORMATION.

PATIENT SIGNATURE

DATE

Fig 2-6 Consent for payment to a nonparticipating provider, National Heritage Insurance Company—State of Maine.

minimal knowledge of patients' rightful benefits, which results in many more denials requiring more appeals and Fair Hearings so that patients can obtain their rightful coverage. If you are a nonparticipating provider, it may be helpful to not accept assignment on Unisys patients. Have patients pay for their treatment following the HCFA guidelines and encourage the patient to obtain rightful benefits individually. The patient can often go to the military personnel manager at the nearest military base for assistance. You can also have the patient enlist the aid of military attorneys to receive rightful Unisys benefits.

Veterans Administration (VA)

The VA is a federally funded program for veterans of the military and other government agencies such as public health. Most of the VA-re- quired maxillofacial prosthetics treatment is done at VA hospitals by VA-cmploycd maxillofacial prosthodontists, completely bypassing insurance issues. If there is no VA maxillofacial prosthodontist in the area, the VA may send the patient requiring treatment to another VA facility to be treated by VA personnel at that location. Limited VA funds for specialists and treatments not available locally arc available when long-distance travel to another VA facility would create a hardship for the patient. The VA also follows HCFA guidelines as to reimbursement levels for the CPT code procedures that have RVU values but has flexibility on reimbursement for procedures that are not coded under those specific codes, which would be submitted under the 21089 code. You will need to get written approval from the local VA hospital prior to beginning care and will need to submit pretreatment estimates of treatment necessary for that patient.

Medicaid (Indigent, Title 19, Welfare, or Low-Income Insurance)

Medicaid may have many different names in different states and is administered by each state. Patients who meet low-income guidelines are eligible. There is great variation in the different states in recognition and understanding of the need, cost-effectiveness, and reasonable reimbursement levels for maxillofacial prosthetic services. Providers have to negotiate with their state's Department of Human Services (department name may vary from state to state) to obtain reasonable coverage. If coverage is obtained for maxillofacial prosthetic services it is often at such a low[1] level that one cannot afford to treat patients with this type of coverage. It may be impossible to provide maxillofacial prosthetic care except on a charitable or transitional basis.

If the patient has Medicare and Medicaid, the provider must accept assignment with Medicare as the primary payer and balance bill to Medicaid (the state). Often Medicaid will not pay any of the balance, stating that Medicare had already paid more than they would have allowed. If Medicaid refuses to allow any coverage on maxillofacial prosthetic services, if may help to have the patient contact low-income legal aid (the names of these agencies may vary from state to state) to advocate on the patient's behalf. The state has a moral and legal responsibility to provide necessary care for patients in this program. It is important to make the state government accountable for their actions and to live up to their responsibilities. Always try to get the exact name of the person making the decisions of denial. Do not accept "this is policy" or "it is from a committee decision." Ask for written denials and copy of state laws that deny this coverage if they use this argument for denials. Most states have definite time limits within which a decision on approvals and denials must be made. You need to know the state laws to be effective against state bureaucracy. Be very careful when the patient's social worker calls and states that the patient will be covered for specific medically necessary care. The social worker may not understand treatment or coverage limitations and probably does not have the authority to authorize coverage, but it can often be helpful to get the social worker to advocate for the.patient. Tell the social worker, "As soon as we get written authorization for the service covered and the level of reimbursement, we will be able to initiate treatment to help your patient. If you can help expedite this approval process it would be greatly appreciated." Many states are also moving to managed care HMOs for Medicaid patients, adding one more layer of bureaucracy to obtain coverage.

Crippled Children's Program

The name of this program varies from state to state. The state administers the program with federal money to support medical treatment for children affected by congenital defects. Guidelines also vary from state to state and usually only cover children to the age of 18. The income guidelines for this program are usually much higher than Medicaid and are based on a higher percentage of the federal income poverty level for that state. This program provides reimbursement as either primary or secondary payer for children with congenital defects. The patient's private insurance, if any, is primary, with the Crippled Children's Program helping to pay copayments and deductibles. This program can be quite beneficial to many families that face long-term medical treatment and rehabilitation for their children with congenital defects. People administering these programs are usually aware of and appreciate the need for maxillofacial prosthetic services.

If there is a cleft palate team in your area, become its maxillofacial prosthetic consultant. Being a member of this group can be of very real benefit to the group and to patients, as a prosthodontist will be involved with the treatment planning and can include prosthodontic treatment as an option when treatment needs are being formalized. By being a part of the treatment team you can help educate both patients and other professionals in maxillofacial prosthetic procedures so that the child can obtain optimal treatment. Directors of these programs are very concerned about children's welfare and wish to obtain the very best treatment possible for each child and are very supportive of maxillofacial prosthetic treatment. After you have examined the patient and decided on treatment needs, but before committing to care, it is imperative to perform a pretreatment estimate and get written confirmation from the Crippled Children's Program not only for coverage but also for reimbursement levels. Even though coverage is usually only to the age of 18, having an approved treatment plan in effect usually results in the program continuing to reimburse the provider until the treatment is completed.

Department of Vocational Rehabilitation

Under vocational rehabilitation programs you must show a direct correlation between maxillofacial prosthetic treatment and the patient's employability. For example, if the patient has an unrepaired cleft with significant velopharyngeal incompetence, constructing a pharyngeal obturator can improve speech and allow the patient to apply for and perform a wider range of jobs. As with social workers, vocational rehabilitation counselors may indicate coverage for a specific treatment, but again, they may not understand how reimbursements are determined. It is critical to get written approval prior to proceeding with care. Still, the vocational rehabilitation counselor can be an advocate and assist in obtaining treatment coverage. As before, it is important to have not only written approval of treatment but also the reimbursement level.

Worker's Compensation

Worker's compensation is for patients who sustain on-the-job injuries, usually involving trauma. Each state has a different type of coverage but all are interested in getting the patient off of Worker's Compensation and back to work. If the patient requires maxillofacial prosthetic services to rehabilitate, coverage can usually be obtained. Often the patient recovers from the initial injuries and returns to work but still requires long-term maxillofacial prosthetics such as implants, obturators, fixed prostheses, and other treatment. If you are working with other medical specialists, such as oral and maxillofacial surgeons or plastic surgeons, they can reinforce the need for maxillofacial prosthetic treatment through the Worker's Compensation program. Again, it is important to get written pretreatment estimates and approvals before proceeding with treatment.

Private Insurance Carriers

Historically, reimbursement levels of private medical insurance carriers were based on compilation of past submitted fee data. This is changing as the RBRVS system is adopted by carriers. In the past each carrier collected data individually to determine reimbursement levels. This method is used much less frequently and insurance carriers now use information clearinghouses to collect national data. These data are collated and updated quarterly. The information is dien sold by the clearinghouse back to each carrier with quarterly updates providing data using the national information and RYU values. The primary companies are St Anthony's Publishing, Reston, Virginia, and Medicode, Salt Lake City', Utah. The AAMP was pivotal in providing accurate data to both of these companies where none existed previously. They now have accurate data to provide to their clients. Unfortunately, some insurance carriers are not updating their information quarterly or even yearly. After receiving a very low reimbursement level, always inquire where the data they used was obtained and how recently it was updated. One may also obtain this information on the 11 maxillofacial prosthetic codes that have RVU values from Medicode and St Anthony's for a fee. Of course, each insurance carrier can apply any conversion factor to the RBRVS values they wish.

Indemnity plans

This type of insurance is decreasing in availability due to higher policy costs. It allows the patient to seek treatment by any physician he or she wishes. These companies usually provide data to national clearinghouses such as Medicode and St Anthony's to obtain quarterly updated RVU values for which they will then apply a conversion factor to determine reimbursement level under different policies and to set policy premiums. Each provider can choose to participate or not participate. Usually the patient pays an initial yearly deductible and then the insurance company pays 80% of approved charges (they may or may not pay your usual and customary reimbursement). The patient then pays the 20% balance until a certain level of out-of-pocket expenses is reached, then the insurance company pays 100% of approved charges. Each year the process starts over again with new deductibles and copayments. It is important to know when the policy year begins and ends. If you choose to participate with an individual insurance company, you are agreeing to accept payment at their approved charge level. The patient will only be billed for the deductible and their copayments. If you do not choose to participate with an individual company, you can balance bill the patient.

The insurance company's penetration and dominance in your market area and your maxillofacial competition will determine whether you decide to participate or not. Each situation in each area is unique. If you are the only maxillofacial prosthodontist in your area it may not be as critical to participate and you can negotiate individually with that company. If you do not have a long-term familiarity with that insurance company and you do not know if it will pay a fair and reasonable level you are comfortable with, you should do a pretreatment estimate and get a response in writing for the coverage as well as the levels of coverage prior to proceeding with any long-term care. If the company is reasonable and timely in its payment levels, it may be of benefit to participate with that company.

If you work in a hospital, medical or dental school, or a large group practice you may have less flexibility in these negotiations and be bound by institutional policy. The insurance company in this type of policy assumes the risks of the amount of payment it is required to make over the course of the year according to the contract signed with the employers. Pricing is adjusted to reflect what the market will bear. These plans also have to comply with both federal and state medical insurance guidelines.

Self-insured private plans

Many large corporations and employers decide to self-insure and accept the risks of the amount of payment levels they are required to make. The reason that employers choose this option is that they are exempt from state and federal insurance guidelines for coverage and can set their own treatment guidelines and levels of coverage, either higher or lower than state mandates, tor example, if a state mandated 90 days of mental health hospital coverage, a self-insured company may allow only 20 days of mental health insurance coverage per year. A corporation will usually hire an insurance company to administer the plan for a set fee following its own insurance guidelines. This can be an indemnity plan, a managed care type of plan, or a combination of these. Each of these plans varies by company depending upon the company's goals, wishes, and attempts to reduce costs and keep employees satisfied. Providers must decide whether to participate or not to participate depending on individual situations as discussed previously, but if a self-insured corporation is a major employer in your area it may be necessary to participate to obtain your market share of maxillofacial prosthetic patients.

Managed care (HMOs and PPOs)

Due to the continued rise of medical costs, employers are looking for ways to reduce these expenses. Managed care insurance companies are becoming more influential with increased market share every year. There is a wide variation of percentage market share depending upon the area of the country. There are varying levels of restriction of care depending upon the type of managed care program that your patient is in. Third-party carriers may decrease costs and care by requiring approvals through a primary care physician, delaying treatment approval and reviews of treatment needed, reducing reimbursement levels, and denying care. This gatekeeper system exists in all managed care policies in varying degrees, which may restrict access to specialists such as maxillofacial prosthodontists. All patients have to have a primary care physician to oversee their treatment and to make the appropriate referrals to specialists they deem necessary. The primary care physician often knows little about the maxillofacial prosthetic treatment being recommended. Unfortunately, many of these HMOs create financial disincentives for the primary care physician to refer to specialists. The HMO will often withhold a percentage of the fee that the physician usually receives for the treatment that he or she provides to patients over the course of the year. This holdback is then used to pay out-of-network specialists such as maxillofacial prosthodontists for treatment needed. If this fee is not used at the end of the year the primary care physicians may receive a bonus of unused holdback fees. This method causes conflict of interest regarding patient needs.

Most HMOs only allow patients to go to providers in their network who have agreed to participate. Again, each provider must make an individual decision whether to participate and become part of the HMO network or not to participate and be out of the network. Providers in the network are listed by that company and patients will be encouraged to go to those offices. Some plans allow patients to go out of network but the patient will have to have a higher co-payment than if they stayed in the network. Providers not in the network can still receive usual and customary reimbursement by billing patients the balance unless the provider has an agreement with the HMO for that individual patient. If one decides to participate in an HMO network, it is important to negotiate with the carrier and get a determination in writing that is very clear. Legal counsel is recommended to review agreements. Managed care companies also can arbitrarily reduce payment reimbursement levels or terminate your contract with a certain number of days notice. Even if the managed care company terminates your contract, you may still have patient treatment responsibilities legally and ethically. If you are in an institution or hospital setting, you may be locked into an unfavorable contract. It is important to become involved in the negotiations with these carriers so that fair reimbursement levels can be obtained. Maxillofacial prosthodontists have much higher overhead, 65% to 70%, than the average medical practice and agreeing to an unfavorable contract may result in providing care that costs more than the reimbursement levels. One cannot provide that type of treatment for any length of time and remain solvent. If a managed care company does not have maxillofacial.prosthodontists in its network, then patients may be sent out of network for treatment. The reimbursement levels can then be negotiated with the company's medical director on a case-by-case basis.

Denials of Treatment by Insurance Carriers

Unfortunately, insurance denial of required medical maxillofacial prosthetic service is a fact of life in treating maxillofacial prosthetic patients. Frequently, this is due to ignorance on the part of personnel who process these claims. Often, when someone sees a DMD or DDS, the claim is denied and the other information submitted, such as claim forms, letters describing treatment, and surgical reports, arc not even looked at. Due to the very low volume of maxillofacial prosthetic claims that are encountered, it is easier for claim processors to deny and get the claim off their desks than to do the necessary research to understand the claim and process it correctly. Many companies have quotas on how many claims need to be processed per hour by each employee.

Claim Tracking

It is critical, then, for each maxillofacial prosthodontic office to have a well-organized system of tracking these claims once they are billed and submitted. Often maxillofacial prosthetic claims are not acted upon quickly due to the above factors, so close follow-up is imperative. If the insurance company has not acted on submitted claims or pretreatment estimates within 30 to 45 days, call about the claim status. Again, difficult and unusual claims are often “lost.” A fax machine is invaluable to allow immediate resubmission of the original claim to a specific person and thus prevent additional delays. The fax machine also can record exact date and time of the resubmission. It is in the insurance company’s best interest to delay payment of claims as long as possible. When calling an insurance company to inquire about the status of the claim, always ask for the first and last names of the person you are talking to and confirm the spelling. If the person knows you are writing down this information he or she will be more apt to follow through and correct the problem. Also, date and document all telephone calls and written correspondence in the medical chart. Many claims are denied due to a lack of understanding of maxillofacial prosthetic treatment by the insurance company’s personnel. Once this information is supplied and corrections are made, claims are often correctly paid in a timely manner.

Why Claims are Denied and What to Do

By increasing denials for needed maxillofacial prosthetic treatment, managed care insurance companies are attempting to decrease costs and expenditures at the provider’s and patient’s expense. To increase market share, many managed care companies give artificially low premium levels and then try to reduce losses by increasing denials and limitations of care or by incorrectly classifying maxillofacial prosthetic treatment services as DME (durable medical equipment). As discussed earlier, durable medical equipment is provided by nonphysicians; it includes such items as wheelchairs, hospital beds, etc, but docs not cover maxillofacial prosthodontic services. Insurance companies try to put maxillofacial prosthodontic services in this category because they often have very low limitations on this type of coverage per year. It is clear from the placement of maxillofacial prosthetic procedures in CPT manuals that these are not DME procedures.

Insurance companies also try to improperly code maxillofacial prosthetic services as dental work. CPT code books and HCFA clearly classify' maxillofacial prosthetic services as medical procedures and therefore they should be covered under medical insurance policies. Insurance companies that do this are trying to shift the responsibility' of paying for medical coverage to dental insurance policies because of their minimum benefits. The same company may have both policies.

When there is a denial of coverage, it is critical to find out who, by name (first and last), made the decision so that this person can be held accountable when appeals are made. Insurance companies do not like to give out this information, so you must try to work your way up the chain of command until this information is obtained.

Making appeals

If denials of care continue, steps need to be taken so the patient can receive his or her rightful benefits. The first step is to talk to a claims person and then his or her supervisor. Always get the exact name, first and last, and time and date for documentation. If claims people say they will get back to you, ask for a time and date that this will happen and document it. Also ask for a direct line telephone number for the individual you arc speaking with. If you do not hear by that date, have your office get on the telephone, contact that person by name, and ask what the status is.

Often insurance companies will say the claim is not covered because it is dental and their policy does not cover “teeth and gums.” This language does not apply to maxillofacial prosthetic treatment services. The denial is usually due to lack of understanding by the medical insurance company’s personnel. Often the personnel making the initial decision have had minimal training and review's arc done by an LPN w'ho knows nothing about maxillofacial prosthetic treatment. Always ask to talk to the company’s maxillofacial prosthetic consultant and ask for the consultant’s name. This can throw them off balance because usually there is no such person. If after working up the chain of claims processors and supervisors no success is obtained, the next step is to talk to the medical director. Unfortunately, there is a wide range of ability’' and competence in medical directors. If you can get a knowledgeable person willing to learn and understand the treatment needed, you may be able to solve the problem and not need to go further.

All insurance companies have an appeals process when claims arc denied, and patients and maxillofacial prosthodontists may need to avail themselves of these. Most of the time the appeals processes arc not done by independent people (although this is changing due to some recent state law's in regard to past HMO abuses) and are done by other personnel within the company.

Patient advocacy

Ultimately, a patient may have to become his or her own advocate for treatment needs. If the patient is not capable, a family member or friend can provide this role. It helps if that person calls the insurance company and complains and demands explanations and reasons for denial of medically necessary treatment. That person also needs to be instructed to get names (first and last), dates, and to keep notes of conversations that take place. It is also important to teach the patient correct terminology for effective communication.

If that patient works for a large company, he or she can also contact the personnel office and/or union representative, if the company is unionized, to obtain help. Companies that arc paying the premiums have a lot of say in the coverage provided within the company policies. Although a self-insured company (see previous discussion) may hire a company to manage and administer the claims, it still has the ultimate authority' to make decisions on the coverage it w-ants for its employees. If enough employees are dissatisfied with their medical coverage, the company may choose to change medical insurance carriers w'hen their contract renewal comes up, to avoid personnel problems. This can be strong leverage to help obtain rightful coverage for your patient. Another method found to be effective is for a patient with an obvious defect to present to his or her company’s personnel office and remove the prosthesis. This can have a dramatic effect and get immediate change of unreasonable policies and denials.

Insurance commissioner

If the above methods are unsuccessful, other avenues can be pursued to obtain the patient’s rightful benefits. Each state has a state insurance commissioner who regulates all insurance sold in that state, including medical insurance. The state insurance commissioner ensures that people are treated fairly by insurance companies within their own guidelines. Usually only patients or employers can write letters to the insurance commissioner, but patients often need guidance on how to do this. It is important to provide them the correct address and name of the insurance commissioner and to have them stress the medical necessity' of denied care. The patient must document efforts that were made to try to reverse this decision at a lower level before writing to the insurance commissioner. It is important to stress medical necessity of required treatment and how it affects that person's life individually. The insurance commissioner definitely does pay attention to complaints and will contact the appropriate insurance company and demand explanations for denial of coverage. Patients should send copies of the letters of complaint to their employer, their provider, and their medical insurance company. In extreme examples of repeated abuse, insurance companies can have their licenses to write insurance in a state revoked. Contacting the insurance commissioner can be an effective tool to get rightful medical coverage for individual patients.

If an employer is self-insured, it may be exempt from state insurance regulations. The insurance commissioner may have no jurisdiction over this company; this is due to ERISA, the Employer Retirement Income Security Act, which is federal legislation. However, the employer must follow its own plan documents. The patient can request a copy of these documents for review to see if a medical service is specifically excluded. The self-insured company also has the latitude to allow exceptions to coverage if it so desires. Complaints regarding continued denial of coverage, not following plan documents, or unreasonable denials can be filed with the Department of Labor, Pension Benefits and Welfare Administration. The patient will need the telephone number of the regional office, which can be obtained from the local Department of Labor. Problems should be discussed with the duty officer, who can explain the correct procedures to follow in filing a Department of Labor complaint. The Department of Labor will investigate the complaint to determine whether this company is following ERISA guidelines.

Congressional support

Contacting congressional representatives, especially if the patient knows them personally, can be very effective in getting insurance companies and legislatures to be accountable. State legislatures can be helpful for state and local problems such as Medicaid and local insurance companies on a state level. In dealing with federal contracts such as Medicare and national companies, federal representatives and senators can be very effective in getting their attention and cutting through much of the bureaucracy.

Legal approach

If required treatment continues to be denied, legal action may be necessary. Suggest that the patient hire an attorney. It is important to get an attorney who is knowledgeable about and experienced in medical insurance issues. Often if the amount is large enough an attorney will agree to take the case on a contingency basis, taking a percentage of the amount of money reimbursed to the patient. If a number of patients from the same company arc having trouble with coverage, they may be able to file suit as a group. Often after receiving notification of legal action, the insurance company is much more motivated to try to come to a reasonable settlement. This action can be an effective tool to get patients their rightful benefits and can be very effective for a long-term problem with one company.

Media approach

The media, such as local newspapers, local television, and radio, are often looking for newsworthy' items. This is especially true as many recent managed care abuses are presented in the press. Reporters are often looking for particularly dramatic human interest stories. The insurance companies do not want this type of negative publicity.

Summary

The medical insurance industry is going through great change with a major shift from traditional indemnity insurance to self insurance and to managed care in its many forms. Reimbursement concepts arc constantly changing due to media publicity regarding medical issues, public discontent, employer pressure to decrease costs, lack of coverage for a percentage of the American population, lobbying by different groups, and political pressures at the state and federal levels. Unfortunately, most insurance carriers and their personnel have no idea what maxillofacial prosthetics is and how it is paid for. There is a general need for the provider to educate insurance companies on what we do and the cost-effectiveness of our treatments for our patients (their clients). This is becoming increasingly difficult since employers constantly change their types of insurance and insurance carriers, requiring new educational efforts. There is also a great expansion of the number of insurance carriers with varying permutations within each that is competing for market share and an increased base of clients. Another difficulty is that insurance companies have constantly changing personnel, so there is a constant process of re-education of new personnel regarding maxillofacial prosthetic procedures.

It is important for the patient and professional to advocate for obtaining medical insurance coverage for medically necessary maxillofacial prosthetic services which are clearly covered procedures. Patients should receive their rightful benefits under medical insurance policies and not be unfairly denied treatment and rehabilitation due to the lack of understanding by insurance companies or cost-containment pressures.

Each office has to decide how to handle financial reimbursements for services provided. If you are part of an institution, hospital, medical or dental school, some of these decisions may be out of your control, made by individuals who do not understand maxillofacial prosthetic issues such as extraordinary overhead expense. It is important that personnel who do the negotiating be educated so that adequate reimbursement levels can be realized.

Regarding Medicare patient billing, one must follow Medicare guidelines as outlined in this chapter, but in the private sector, options of payments are:

1. Patient pays for treatment at the time of service; the insurance company is then billed and the money goes to the patient.
2. Patient pays only the copayment at time of service; the insurance company is billed for the balance. This option is best only when dealing with an insurance company with a proven track record.
3. The medical insurance company is billed first, and after payment is received, the patient is billed for the balance.

It is important for patients to understand that we work for them, not for the insurance companies (obviously there are some exceptions). Patients are ultimately responsible for their treatment and welfare and are financially responsible for their own medical care. Exceptions are for patients covered by Medicare, Medicaid, or HMOs that you have agreed to participate with.

Maxillofacial prosthetics is rewarding and satisfying, but if reimbursement levels are too low the financial disincentives will be so high that maxillofacial prosthodontists redirect their practices from this subspecialty to more traditional types of prosthodontics. In most practices maxillofacial prosthetics involves a small percentage of patients. Maxillofacial prosthetics is a cost-effective, medically necessary treatment that might become unavailable, which will further increase costs to patients, insurance companies, government agencies, and society. Patients will suffer and will not be able to obtain needed rehabilitation. The government and medical insurance companies need to be educated and live up to their responsibilities to their clients so this does not happen.

The Radiation Therapy Patient: Treatment Planning and Posttreatment Care

o Donald C. Kramer, DDS, MS

Discussions of treatment modalities presently utilized in the medical management of the cancer patient frequently include the importance of the role of the dentist in patient care. The prostho- dontic treatment of head and neck cancer patients, and its role in improving quality of life, is well recognized. Prior to the early 1960s, the dentist, or more frequently the prosthodontist, was engaged almost exclusively in dealing with the dental rehabilitation of the head and neck cancer patient who had undergone ablative surgery.

With the increased use of radiation in the 1960s and cytoreductive drugs in the 1970s, dentistry was challenged with the task of developing treatment regimens for the oral complications associated with these forms of therapy. Although relatively large numbers of patients were treated, the role of the dentist in managing the oral complications associated with various cancer therapies was not completely understood. This was the case despite the fact that the National Institute of Health in a Consensus Development Statement estimated that as many as 400,000 patients developed oral complications as a result of cancer treatment. The same document noted that “at a minimum, oral complications are painful, diminish the quality of life, and lead to significant compliance problems, often discouraging the patient from continuing treatment” (NIH, 1989).

As time has progressed, the oncology patient’s need for early and continual dental care has been proven to be beneficial by a number of clinicians and is now recognized, for the most part, by the physician oncologist. Today, the dental oncologist at most major cancer centers and the oncology-oriented general dental practitioner in the private sector are valued, participating members of oncology treatment teams.

Treatment Rationale

Early dental intervention is a most important factor in preventing the possibility of infection during active phases of chemotherapy and in reducing the potential for both short- and long-term problems in the irradiated patient. Ideally, the dental examination and necessary dental treatment should be performed prior to the onset of definitive cancer treatment. This requires the complete cooperation of the physician oncologist and is predicated on his or her assessment of the severity of the patient’s disease, general health status, and the aggressive nature of the tumor. It is ultimately the physician’s responsibility to determine, after dental consultation, whether or not invasive dental procedures will compromise the patient’s cancer therapy.

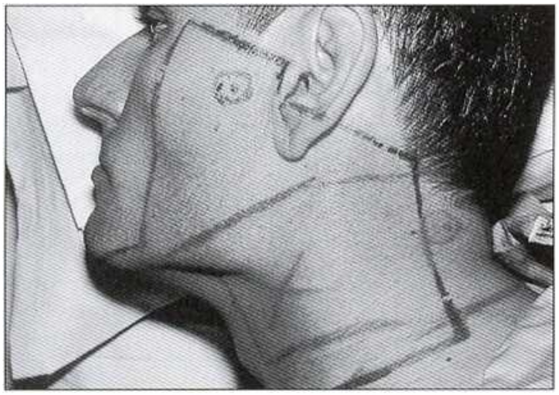


Fig 3-1 Outline of radiation fields to be used for the treatment of a squamous cell carcinoma of the nasopharynx. The size of the fields, dose, tissue volume, and type of radiation are all factors in the degree of long- and short-term morbidity the patient will experience.

Oncology patients represent a broad cross section of the general population and experience the same dental pathology routinely seen in any practice. Frequently these patients are elderly, have poor oral hygiene, and in many instances, because of low economic status, have received limited dental care. The patient and his or her family are justifiably overwhelmed with their "cancer problem" and do not completely understand the emphasis placed on dental care. The initial dental appointment provides an excellent opportunity for the dentist to gain the family's confidence, establish a position as an information source, and explain the causes for concern. It is also the logical time to emphasize the importance of a total commitment to the treatment regimens proposed.

It is advantageous for the patient to have a basic understanding of the short- and long-term effects of radiation to the head and neck. It should be simply explained that over the first few weeks of therapy, depending on the location and size of the treatment fields, volume of tissue treated, and type of radiation employed, the patient will experience, in varying degrees, mucositis, xerostomia and a concomitant change in oral microflora, loss of taste, and increased sensitivity to spicy or strong-tasting food (Fig 3-1).

Long-term problems include reduced potential for bone healing and the risk of developing osteoradionecrosis. The patient will experience permanent loss of salivary function leading to a significant change in both the quality and quantity of saliva and an increased potential for dental caries. Additionally, the patient should be told about increased susceptibility to oral infections of candidiasis and possibly, over time, trismus (technically, muscular fibrosis) that severely limits the ability to open the mouth, making dental procedures difficult to perform (Joyston-Bechal, 1992). It is imperative that the patient and family understand that the long-term morbidity associated with radiation will last the remainder of the patient's life. The dentist's initial examination must focus on the dental implications of these short- and long-term effects.

Dental Examination and Treatment Plan

Restorative Procedures and Dental Extractions

Full-mouth or panoramic radiographs are necessary, as is a comprehensive clinical examination of the periodontium and oral soft tissues. An assessment of the patient's oral hygiene is an important element in the initial examination. A dental prophylaxis and review of oral hygiene procedures should be accomplished as quickly as possible. The patient should be examined carefully for dental caries. Definitive restorations should be placed, and teeth considered nonrestorable or salvageable with endodontic therapy should be extracted. The required extractions must be accomplished expeditiously since a healing period of at least 10 days to 3 weeks is essential before radiation treatment begins. Proposed extractions must be discussed with the radiation oncologist and an understanding reached regarding the time available for healing. When surgical removal of a tumor is planned prior to radiation, teeth can be conveniently removed in the operating room at the time of tumor surgery, thus ensuring an adequate healing period. It is generally advised that teeth be removed with minimal trauma and the extraction sites be closed primarily. Antibiotic coverage may improve the potential for healing in the case of diabetics and other medically compromised indi vi duals.

Periodontally involved teeth exhibiting moderate to severe mobility should also be considered for removal. Some thought must be given to the long-term prognosis of the teeth in question. The patient’s ability and willingness to perform all recommended oral hygiene procedures will also help determine which teeth can be maintained. In questionable situations, it is perhaps more prudent to err on the side of aggressive tooth removal, since extractions following radiation treatment will present an increased risk of osteoradionecrosis. It must also be remembered that wound healing will be compromised, and extensive periodontal surgery following radiation will be contraindicated.

Frequently, the dentist is faced with the decision to extract all remaining teeth. This should be tempered to some degree by the knowledge that the patient rendered completely edentulous with no previous denture experience may find the process of adjusting to complete dentures a difficult one. Soft tissues within the radiated field will be easily irritated by the prosthesis. The lack of saliva will exacerbate this condition and also affect prosthesis retention. It is advisable to consider maintaining strategically positioned, periodontally sound teeth to be used as abutments for removable partial dentures or complete over- dentures. Because irradiated bone loses the ability to remodel, radical alveolectomics must be considered for those patients who are candidates for removable prosthescs. Removal of tori and exostoses will help reduce soft tissue problems and improve the opportunity for prosthodontic success.

Patients who present with partially erupted or impacted third molars are a particular problem since a number of valid arguments can be made for and against extraction. Two issues are of importance in regard to the decision to extract these teeth. The principle concern is, once again, the amount of time the physician oncologist is willing to allow for healing. Impactions requiring extensive bone removal may take longer to heal and are at greater risk for infection, necessitating a possible delay in the start of the radiation treatment. These extractions may be a greater problem in the older, physically compromised individual compared with a younger, healthier patient. Since the fully impacted tooth does not precipitate many major, immediate problems following radiation, the decision to extract or not extract these teeth can only be reached after careful review of all factors.

Partially erupted teeth must be considered for extraction, particularly if they have been the cause of previous episodes of pericoronal infections. Potential restorative and surgical procedures will be difficult following radiation since resulting trismus will limit access and surgery will result in a risk of compromised wound healing. A limited ability to open makes surgery and restorative and endodontic procedures in posterior quadrants very challenging and has a detrimental effect on the quality of care provided. It is certainly an advantage to extract these partially erupted teeth prior to radiation.

Preradiation Prosthodontic Care

As noted previously, many head and neck oncology patients are elderly and have experienced limited dental treatment. A number wear removable complete or partial dentures, and although in the opinion of the patient the prostheses arc serviceable, they may or may not conform to acceptable prosthodontic standards.

Regardless of the condition of the dentures, little definitive prosthodontic care is necessary prior to radiation. The severity of resulting mucositis will limit the patient's ability to tolerate the prosthesis during therapy, whether or not retention or occlusion is adequate. Since patients may experience a substantial weight loss over the treatment course, sufficient change will have occurred in the soft tissues to warrant the fabrication of new dentures once radiation is complete. There is little advantage to relining ill-fitting dentures since the procedure can be moderately expensive and will not be a factor in patient comfort during various stages of mucositis. Soft, temporary reline materials, because of their surface porosity and abrasiveness, make hygiene procedures difficult, serve as a potential reservoir for fungal growth, and may be a source of additional mucosal discomfort.

Patients are advised that they will, in most instances, be better served by not wearing dentures during therapy. The patient must be cautioned that continuing to wear the dentures may be the source of significant additional mucosal irritation and lead to delayed healing following the completion of radiation therapy. In most instances, the patient will object to being without dentures during therapy for the usual cosmetic and functional reasons.

The clinician should approach this situation with a sympathetic car. It is important to the psychological well-being of the cancer patient that a degree of normalcy exists in daily life. Such patients have been bombarded with discussions of serious, potential problems resulting from radiation and then are asked to suffer the additional indignity of going without dentures. It is important for the patient to feel in control of the decision regarding the use of dentures. More often than not, a decision will be made to heed the advice of the dentist.

Dentate patients with metallic crowns or fixed partial dentures in the treatment field may suffer significant irritation to adjacent soft tissue as a result of backscatter. This problem can be minimized with the use of a custom-made, soft plastic stent. The stent should be of sufficient thickness to displace the soft tissue in buccal and lingual directions. In some cases, the patient's fluoride carrier may be used for this purpose (Scrimger, 1977).

An increasing number of patients with dental implants are being seen at treatment centers. This topic is comprehensively discussed in other chapters of this book. Suffice it to say that much controversy exists regarding the need to remove the implants before radiation. In my experience, radiation therapists have generally decided to remove implants positioned in the treatment fields. Much clinical research is being done today regarding this problem as well as determining the efficacy and safety of placing implants in irradiated bone.

Dental Management During Radiation Therapy

Mucositis

One of the earliest effects of radiation to the oral cavity is the development of severe soft tissue irritation or mucositis (Tig 3-2). The soft tissue in the treatment field, after a week or two, demonstrates a moderate amount of erythema. As radiation continues, the mucosa may exhibit varying degrees of desquamation and frank ulceration. Resulting pain and dysphagia make it difficult for the patient to eat a well-balanced diet, resulting in what may be a significant weight loss. It may be necessary to interrupt therapy if the weight loss becomes critical. The severity of the mucositis is influenced by a number of factors and is not always predictable. Patients with a history of alcohol abuse or smoking, for example, who continue these habits during radiation suffer the greatest morbidity. Acute mucositis begins during the second or third week of radiation therapy and subsides within 8 to 10 weeks once treatment is completed (Fig 3-3).

A variety of measures have been proposed to help alleviate the patient's discomfort, the most significant being good oral hygiene (Flemming, 1990). Frequent daily cleaning of the teeth with a soft brush and mild-fasting toothpaste has proven to be beneficial. Frequent oral rinses with

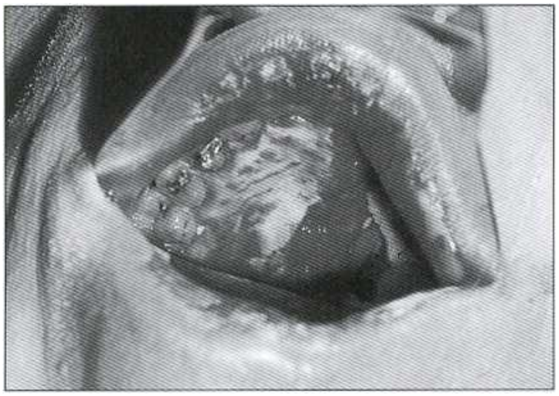


Fig 3-2 Mucositis of the palate following maxillectomy and radiation therapy. There is evidence of erythema, desquamation, and ulceration. Resulting pain and dysphagia make proper nutrition a problem since the patient is unable to use his obturator. Radiation therapy may be discontinued for a period of time if weight loss reaches a critical level.

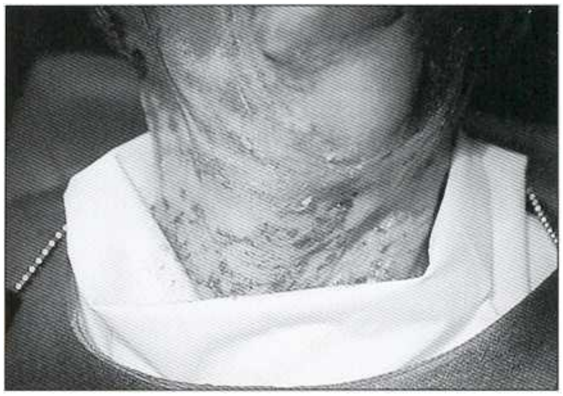


Fig 3-3 Radiation dermatitis involving the skin of the neck. Skin reactions are generally not this severe but do occur when radiation is delivered with external beam. Long-term consequences include epilation and sensitivity to sun exposure.

a combination of salt and sodium bicarbonate in water or dilute solutions of hydrogen peroxide and water appear to have a soothing effect on the affected areas and aid in keeping the tissue clean and moist. Other therapies have included rinsing with Benadryl elixirs, sucrafate solutions, and topical anesthetics. The mucosa should be cleansed with either the hydrogen peroxide or salt solution prior to using Benadryl or sucrafate. This helps remove debris and mucus from the wounds and allows the medication to adhere more intimately to the tissues. Topical anesthetics in dilute form effectively reduce discomfort and can be useful during meals. Since large portions of the oral cavity are anesthetized for a significant period of time, the patient must be cautioned not to inadvertently bite and additionally injure the soft tissues.

Loss of Taste

Loss of taste accompanies radiation to the tongue and palate. This loss occurs rapidly during the first week or two of treatment and in most instances gradually returns to normal once the treatment course is completed. Some questions have been raised regarding the exact cause of the loss of taste. Damage to taste buds and microvilli, disrupted innervation as a result of the radiation, and lack of saliva have all been mentioned as possible contributing factors. The condition is primarily an annoyance but adds to the discomfort of the patient during the treatment course. The loss of taste may lead to lack of desire for food and can be an additional cause of weight loss during therapy. It is a condition the patient must endure with the understanding that it is rarely permanent.

Xerostomia and Dental Caries

Changes in the quantity and quality of saliva as a result of radiation have been well documented in the dental literature (Brown et al, 1978). Beginning with the first course of treatment, salivary flow rates decrease, eventually reaching as low as 1% of normal. Additionally, there is a concomitant increase in the numbers of acidogenic and cariogenic microorganisms and a decrease in noncariogenic microorganisms resulting in a severe, aggressive form of dental caries. Lacking a specific preventive program, the dentist at one time was faced with the unenviable task of continually restoring all tooth surfaces with little

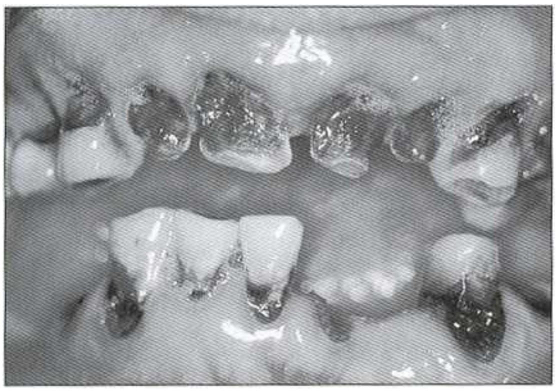


Fig 3-4 Radiation fields that include salivary glands result in a change in the quality and quantity of saliva. There is a resulting increase in cariogenic microorganisms resulting in a severe aggressive form of tooth decay called radiation caries. Preventive regimens include the daily use of stannous or sodium fluoride and good oral hygiene.

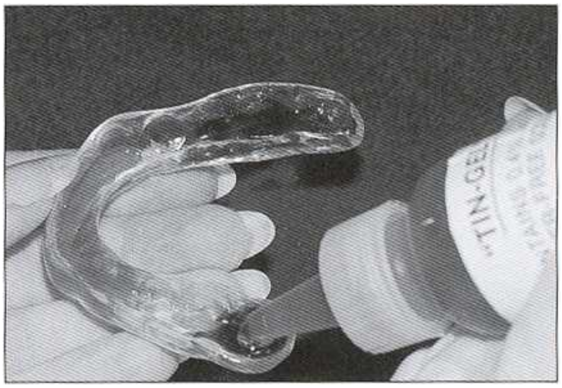


Fig 3-5 Fluoride gels used with a custom tray have been reported to better cover all tooth surfaces than either rinses or gels applied with a brush. It has been suggested that use of the tray simplifies the application process and improves patient compliance.

hope for success. In an effort to reduce long-term complications precipitated by this form of tooth decay, patients were frequently advised to have all remaining teeth, regardless of their condition, extracted prior to radiation (Fig 3-4).

Definitive studies (Dreizen ct al, 1977) regarding treatment and cause of dental caries in the irradiated patient led to the knowledge that the most effective method of treating this condition was through the daily use of topical applications of fluoride. Both stannous or sodium fluoride have been used in a variety of forms (gels, rinses, and toothpastes) with significant success. It has been noted that an additional advantage of stannous fluoride is that it has an antimicrobial effect, reducing *S mu tans* counts. Sodium fluoride, because of its higher pH, is less irritating to compromised soft tissue and is substituted for the stannous form for patients who complain of a burning sensation when using the stannous gel. Gels used with a tray are reported to better cover all tooth surfaces than either fluoride rinses or gels applied with a brush. Some authors have proposed that the use of a tray as a carrier simplifies the fluoride application procedure and improves patient compliance, achieving a better overall effect (Fig 3-5).

Patients must be made to understand that they will need to use fluoride once a day, every day for the remainder of their lives. Clinical experience has demonstrated that discontinuing the fluoride applications, even for short periods of time, may result in renewed cariogenic activity. Preventive programs based on the topical applications of fluoride, coupled with meticulous oral hygiene, can all but eliminate the caries problem. There is little reason for any irradiated head and neck cancer patient to experience abnormal dental caries, providing he or she is fully compliant, monitored regularly, and appropriately counseled by a dentist.

Immediately following the initial prophylaxis and before radiation treatments begin, irreversible hydrocolloid impressions are made. Custom trays or carriers, which extend to just below the marginal gingiva, are fabricated and delivered, taking care to relieve any areas that may impinge on soft tissue. The edges of the tray should be made as smooth as possible to avoid soft tissue irritation. This is an important step since the patient will be expected to use the carrier during therapy while experiencing severe mucositis.

The patient is instructed to carefully brush his or her teeth. Immediately following brushing, the patient is directed to place a sufficient amount of a sodium or stannous fluoride gel into the tray to cover all tooth surfaces. Once positioned, the tray and gel must remain in contact with the teeth for a minimum of 5 minutes. Additionally, the patient is asked not to rinse the mouth for approximately 30 minutes following removal of the tray. As the patient progresses through radiation treatment courses, it is advisable for the dentist to frequently monitor oral hygiene procedures and ensure proper use of the fluoride.

Although the preventive treatment described is generally considered the treatment of choice, several groups of patients experiencing only partial salivary gland dysfunction (Hodgkins' disease patients, for example) may achieve acceptable results by simply brushing with the fluoride gel.

Saliva Substitutes and Sialogogues

The most persistent and certainly the most frustrating morbidity associated with radiation to the head and neck is dry mouth. The condition begins in the first week of therapy and gradually worsens over time. The patient experiences a need to continually lubricate the mouth and is forced to ingest large quantities of fluid to aid in swallowing at mealtimes. There is a disconcerting change in eating habits with an increased intake of soft, moist foods. Food debris accumulates on the oral mucosa and teeth because of the absence of the self-cleansing action of saliva, making oral hygiene much more difficult.

Attempts have been made to stimulate salivary flow rates with sialogogues such as pilocarpine and antholetrithionc (Fox et al, 1986). Therapeutic regimens involving administration of these drugs have proven effective for patients with Sjogren syndrome and for individuals receiving low doses of radiation to limited fields. There is no concrete evidence that the drugs are effective in those individuals receiving high doses of radiation to all major salivary glands.

Saliva substitutes have been developed in an effort to alleviate the discomfort and harmful effects of xerostomia. These products consist primarily of carboxymethylccllulose with various salts and flavoring agents added. Results with the use of the substitutes is mixed, related more to the subjective preference of the patient than to any appreciable therapeutic effect. Patients should be offered an opportunity to try the substitute early in the course of radiation treatment. While most individuals discontinue use within a relatively short period, complaining of stickiness or unpleasant taste, others find it to be of some benefit.

Clinical experience has demonstrated that patients are quite resourceful in developing their own methods of coping with xerostomia. Many carry containers with water or salt and soda solutions with them at all times, rinsing or drinking frequently. Others have been reported to rinse with self-developed mixtures of glycerin and fruit juice or mouthrinses with some success.

Trismus and Fibrosis

Trismus may begin shortly after radiation begins. Clinically, the patient gradually loses the ability to open the mouth. The condition may be exacerbated by surgery prior to radiation and by radiation fields that include the muscles of mastication or the temporomandibular joint. Patients suffering with tumors of the palate, nasopharynx, and maxillary sinus are most likely to develop trismus. If unmanaged, trismus makes eating difficult and the performance of dental procedures almost impossible (Fig 3-6).

Since primary treatment involves exercising the muscles involved, a variety of bite openers or exercise devices have been developed. Each has been proven through clinical use to be of substantial value and, in most instances, effectively increase the oral opening. Positive results are more easily attained with the dentate patient. It must be noted that improvement in the ability to open regardless of the exercise program is not permanent and may regress over a period of even a few hours.

The simplest and least expensive method of exercising is with the use of tongue blades. A number of tongue blades are placed along the occlusal surfaces of the posterior teeth. The vertical opening is increased as an additional blade is added slowly and deliberately to the original stack. The patient is instructed to pause for a few minutes before placing each additional blade (Fig 3-7).

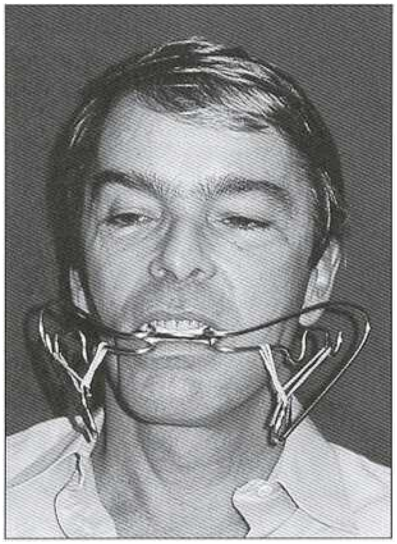


Fig 3-6 Trismus and fibrosis are disconcerting results of high doses of radiation. Daily exercise of the muscles of mastication offers some improvement in the ability to open. Dynamic bite openers of a variety of designs have been proven effective in cases of severe trismus.

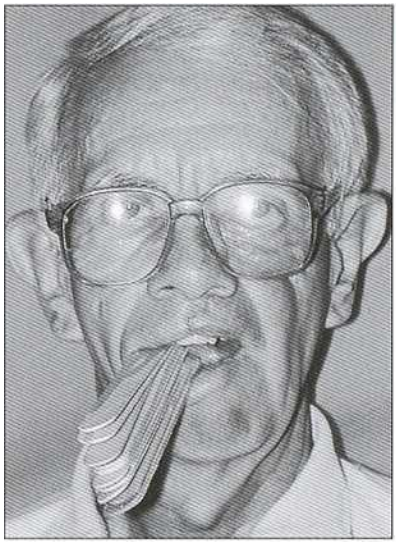


Fig 3-7 The simplest and least expensive method of exercising is with the use of tongue blades. Several of the blades are placed over the occlusal surfaces of the teeth. An increase in vertical opening results as additional blades are added one at a time.

As trismus becomes chronic, there is an appreciable amount of discomfort involved in performing the exercises, regardless of the method used, resulting in patient noncompliance. Chronic trismus gradually becomes fibrosis of the elevator muscles and at this late stage is not amenable to stretching as a solution. Exercise must begin early in treatment, and results are predicated on the patient's willingness to cope with the exercise regimen.

Shielding and Positioning Stents

In an effort to minimize morbidity associated with radiation to the oral cavity, soft tissues not directly involved with tumor can be displaced or shielded (Kaanders et al, 1992). The radiation oncologist frequently uses a tongue blade taped to a cork, for example, when treating lesions involving the tongue. This simple device, in effect, lowers the mandible and tongue, preventing radiation to the nonaffected parotid gland and maxilla to some degree. Over time, dental oncologists in cooperation with radiation therapists have developed more sophisticated shielding and positioning devices that have proven to be useful in limiting radiation effects. The fabrication of one of these stents or splints is time sensitive, since it must be used in the planning of treatment fields. The physician will usually desire treatment to begin as quickly as possible and may have concerns regarding the time involved in fabricating a customized stent or splint. Some radiation oncologists find the fabrication of complex, customized stents unnecessary. This opinion appears to be based more on the availability of an oncology-oriented dentist rather than unsuccessful clinical results. Generally, fabrication is a relatively uncomplicated procedure and can be completed expeditiously using basic prosthodontic clinical and laboratory techniques.

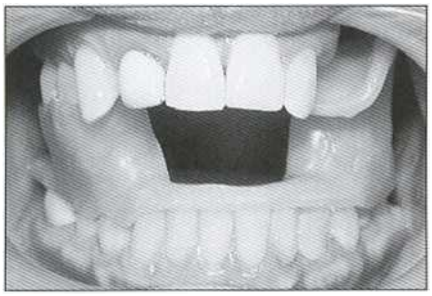


Fig 3-8 Positioning stents serve to relocate tissues not involved with tumor. Long- and short-term complications from radiation can be significantly reduced using these devices. One such stent is designed to position and lower the tongue and maintain the maxilla outside the radiation field. The stent is developed in wax and evaluated in the mouth in consultation with the radiation therapist.

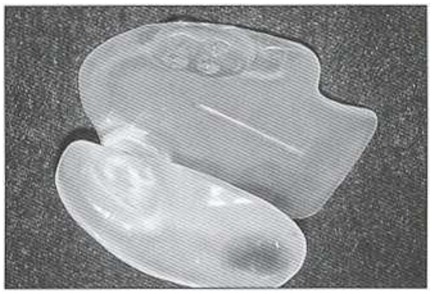


Fig 3-9 The stent is processed in clear acrylic resin and polished. A piece of stainless steel wire is placed in the lingual extension to help identify the dorsum of the tongue on simulator films.

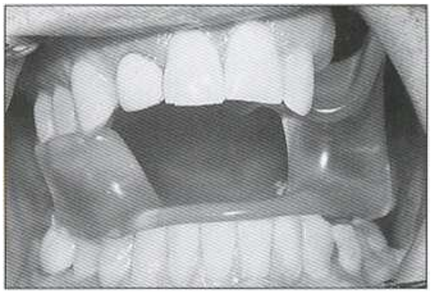


Fig 3-10 The completed stent maintains the soft and hard tissues of the mouth in a stable repeatable position. Adjustments can be made to accommodate changes in vertical opening resulting from trismus. The stent is much more comfortable and positions the tissues more accurately than the tongue blade and cork used by many radiotherapists.

Positioning Stents

One of the most frequently used positioning stents serves to lower the tongue and places it in a repeatable position during therapy. Since the stent also serves to separate the mandible and maxilla in an open position, maxillary structures such as the palate, upper gingiva, and buccal mucosa are spared radiation effects.

Maxillary and mandibular impressions are made with irreversible hydrocolloid. In the case of the completely edentulous patient, the impressions must be properly extended to ensure stabil ity of the finalized bases. An interocclusal record is obtained at the widest opening necessary to ensure that maxillary structures are not included in the treatment field. Casts arc recovered and mounted on a simple articulator. Baseplate wax is softened and placed over the incisal and occlusal surfaces of all the teeth. Two pillars that join the maxillary and mandibular segments and maintain the open interocclusal relationship are fabricated in wax. Two sheets of baseplate wax are then attached to the right and left sides of the mandibular segment. This flat sheet extends posteriorly as far as tolerable, covering the entire tongue and maintaining it in the appropriate treatment position. An opening in the anterior portion of the stent between the pillars acts as a shelf upon which the tip of the tongue rests and serves to help maintain a repeatable tongue position. The waxed stent is evaluated in the mouth, and the radiation therapist verifies tongue position (Fig 3-8). Additionally, an assessment is made regarding the patient’s ability to tolerate the stent, position it correctly, and remove it easily. The waxed stent is flashed and processed in clear, heat-cured or autopolvmcrizing resin. A length of stainless steel wire is embedded in the horizontal lingual extension (Fig 3-9). The wire defines the position of the dorsum of the tongue on simulation films and is of value when planning radiation fields. The stent is highly polished and checked carefully for any scratches or sharp edges that may cause irritation during therapy. The radiation therapist confirms the final treatment fields with the completed stent in place (Fig 3-10).

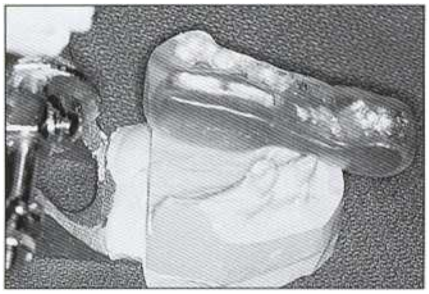
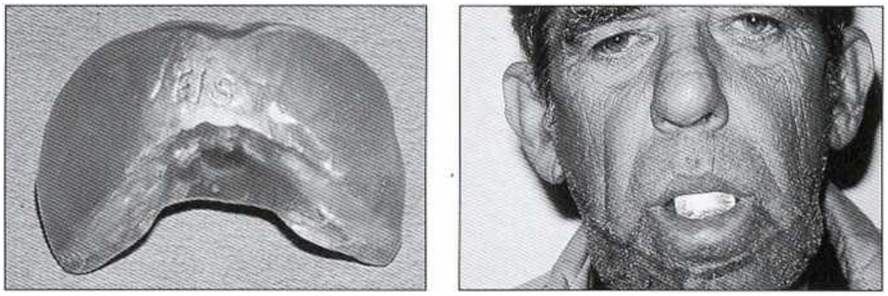


Fig 3-11 It is possible to protect uninvolved tissue when electrons are used to treat tumors of the skin or cheek. A basic design is developed in wax, depending on the needs of the radiation therapist. Once a design is developed and processed in acrylic resin, a portion of the stent is made hollow and filled with a lead alloy. One centimeter of the metal will shield 95% of an electron beam.



Figs 3-12a and 3-12b The shielding stent may in fact serve two functions. In this case, the lower lip is displaced anteriorly and posterior structures are protected from radiation effects. The protruded lip position is repeatable for each radiation course, improving the opportunity for therapeutic success.

Shielding Stents

It is possible when treating tumors of the buccal mucosa, skin, or alveolar ridge with electron beam therapy to protect uninvolved adjacent structures by means of a shielding stent. It is known that a 1-cm thickness of a Lipowitz alloy (Cerrobend, Cerrometal Products, Bcllefort, PA) consisting of silver, copper, tin, antimony, and lead will effectively reduce an 18 MeV electron beam by approximately 95%. The metal is only effective, however, when electrons are used. Generally, an acrylic resin stent is made. A portion of the stent is removed and the metal is heated, poured into the prepared recess, and allowed to cool. The metal is then covered with a layer of acrylic resin to prevent backscatter to adjacent tissue (Fig 3-11).

Maxillary and mandibular impressions are made using a combination of modeling plastic and irreversible hvdrocolloid in air effort to displace the tongue laterally. An interocclusal wax record is made in centric relation at a slightly opened vertical dimension. The impressions are poured and the recovered casts are mounted on a simple articulator in the open position. Baseplate wax is placed over the mandibular teeth on the side to be treated, and the articulator is closed to form an index of both maxillary and mandibular teeth. A wax bolus is formed and attached to the occlusal index. The bolus should extend approximately 1 to 2 cm lingually and contact both the palate and the floor of the mouth. The lingual surface of the stent is made as flat as possible. The waxed stent should be tried in the mouth to confirm appropriate extension posteriorly and sufficient displacement of the tongue.

Once the shape has been confirmed, the waxed stent is flashed and processed in clear, heat-cured or autopolymerizing acrylic resin. The stent is recovered and polished as carefully as possible, making certain that no sharp edges or rough surfaces exist. A recess, extending within 8 to 10 mm of the entire circumference of the stent, is cut into the resin to an appropriate uniform depth dependent on the megavoltage of the electrons to be used. The Cerrobend is heated and the molten metal poured in the hollowed portion of the stent. The metal melts at 158°F, at which temperature, the acrylic resin will not be damaged.

After cooling, the patient’s name can be cut into the metal surface with a round bur for identification purposes. The exposed metal is covered with additional acrylic resin to prevent the metal from contacting mucosal surfaces and to mini- mize backscatter. The completed stent is tried in the mouth in consultation with the radiation therapist. Minor final modifications can be made at this time. It may also be necessary to adjust the stent as treatment progresses to avoid irritation of radiated soft tissues and to accommodate the limiting effects of trismus. In some situations both photons and electrons are used in treatment. Since the tissues must be in the same position when either modality is used, a duplicate stent without the metal is employed during the photon phase of treatment (Fig 3-12).

Modifications can be made in the basic design of the positioning and shielding stents to accommodate the needs of most treatment situations. It may be advantageous to make the stent in several pieces. This facilitates insertion and removal as treatment progresses and trismus becomes a problem.

A number of other stents have been described that function as carriers for radioactive sources and positioning cones. The basic procedures for developing these devices are essentially the same as those discussed above. There are only a few fundamental rules governing fabrication of these stents, and in many instances design is based on the ingenuity of the dentist involved and a cooperative relationship between dentist and radiation therapist.

Dental Management Following Radiation

Mucositis and Loss of Taste

Once radiation treatment is complete, acute mucositis will subside gradually over a period of 6 to 8 weeks. Healing may be delayed for a variety of reasons related to the patient's general health and compliance with suggested preventive measures. Heavy smokers or drinkers may experience longer delays in healing. Since the affected soft tissue will remain constantly irritated to some degree, the patient is advised to continue using rinses previously suggested. The importance of the patient maintaining a program of good oral hygiene cannot be overemphasized (Jacob, 1993). The patient will also experience an improvement in the sense of taste. The length of time necessary for recovery is dependent on the severity of damage to the soft tissue and in some instances may take months. Generally, taste acuity will return to levels that the patient perceives as normal. However, some individuals do complain of slight, persistent alterations in taste.

Xerostomia and Dental Caries

As noted previously the loss of salivary function is permanent, and salivary flow rates have been proven to decrease with time. Oral tissues will remain dry and uncomfortable, forcing the patient to rinse frequently with no hope for a positive therapeutic solution to the problem. A program that includes meticulous oral hygiene, frequent daily rinsing, and use of saliva substitutes offers some hope for temporary relief.

Since dental caries is directly related to the effects of the decrease in saliva, it is essential that the program of oral hygiene and the daily topical application of fluoride be maintained. The patient is encouraged to visit the dentist more often than normal to ensure compliance with hygiene procedures and to detect any increase in cariogenic activity. It is not uncommon for individuals to become lax regarding oral hygiene procedures once radiation is completed. For this reason, the clinician must assume a substantial portion of the responsibility for continually monitoring the patient's oral health. Tooth decay leading to pulpal pathosis can be a serious problem in the radiated patient since extraction of involved teeth is a complicated undertaking.

Candidiasis

Infection with *Candida albicans* may occur during or following radiation. Xerostomic conditions and the change in normal oral flora are thought to be the causes of increased propensity for this infection. One of the early symptoms is an abnormally sore or burning mouth. Clinical examina tion may reveal some generalized inflammation involving the palate and cheeks, but lacking the whitish patches generally associated with *Candida.* Since irradiated tissue may chronically exhibit some erythema, bacterial and fungal cultures should be taken to confirm the presence of *Candida.*

If cultures are positive for the fungus, troches or rinses containing chlotrimazole or nystatin are prescribed. Bacterial infections may be treated with appropriate antibiotics. Treatment is continued for a period of 2 weeks. It has been suggested that meticulous oral hygiene and frequent rinsing with salt and soda or dilute solutions of hydrogen peroxide may have a preventive effect. Some clinicians have reported daily rinses with chlorhexi- dine to be beneficial. Individual patients will, on occasion, complain of increased irritation when chlorhexidine is used.

Clinical experience has demonstrated that *Candida* may be harbored in or on the surface of dentures or obturators and play a role in chronic reinfection. Soaking prostheses in an antifungal solution or dilute hypochlorite for complete dentures has proven to be an effective preventative measure.

Trismus and Fibrosis

Trismus and fibrosis will continue to be problems following radiation. In most instances these conditions will increase in severity with time, leading to oral openings of 10 to 15 mm. Patients will have difficulty placing dentures or obturators, with resultant compromise in nutrition. The condition is only improved with constant exercise. The more frequent and diligent the exercise regimen the more beneficial the result. It is recommended that the patient perform exercises several times each day.

The exercises can be quite painful, the severity of which is directly related to the severity of precipitating factors and the period of time elapsed between exercise sessions. Patient intolerance to the discomfort associated with the exercise affects compliance and has a detrimental effect on results achieved. Exercises should be performed deliberately, followed by periods of rest. Any improvements made in the amount of opening are not permanent, though, and gains achieved can regress in a matter of hours.

Dental Extractions

It is a well-documented fact that patients receiving cancericidal doses of radiation to the mandible or maxilla experience diminished ability to heal when even mild trauma causes loss of mucosal integrity and subsequent exposure of devitalized bone. This condition, defined as osteoradionecrosis (ORN), presents a profound dilemma for the dentist and the patient. Any oral surgery procedures performed following radiation may result in delayed wound healing accompanied by considerable pain and discomfort. Long term, the xerostomic patient is at greater risk for extensive dental decay. Noncompliance with oral hygiene programs, including the use of fluoride, and any progression of periodontal disease may precipitate a need for extractions.

There is a great deal of controversy regarding dental surgery following radiation. Some clinicians have reported few incidents of ORN after removal of teeth following radiation therapy. Evidence has been presented that maxillary teeth in the radiated field can be extracted with little risk. Published clinical studies endorsing extractions have not always defined radiation treatment fields, dosages, radiation type, or even whether or not teeth extracted were in the treatment field. Others have demonstrated that the maxilla is not completely immune from the effects of radiation. A number of incidences of ORN in the maxilla have been reported. Well-planned surgical studies using antibiotics and precise techniques report incidences of ORN from as little as 1% to as high as 30%.

It has been suggested that extremely mobile, periodontally compromised teeth can be safely removed with minimal risk of developing ORN. In fact, patients frequently present for maintenance visits explaining that several teeth have simply exfoliated as a result of advanced periodontal disease. Although not widely advocated, it would appear that in isolated instances, procrastination is an acceptable form of treatment. Whenever

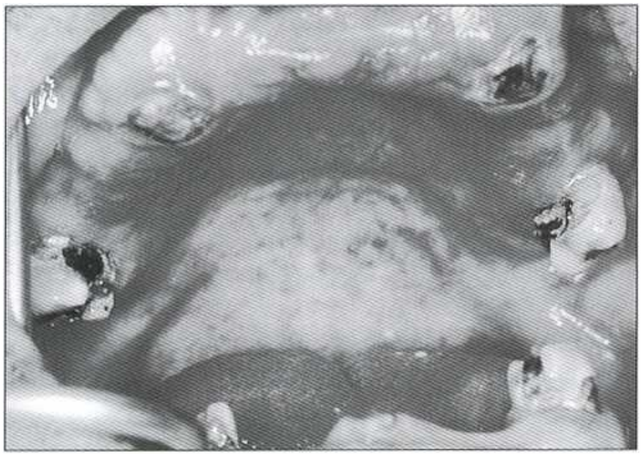


Fig 3-13 It is generally recommended that nonrestorable teeth in the radiated area be treated conservatively. Endodontic therapy may be performed when necessary and the tooth crown amputated at the gingiva. Although usually nonfunctional, these may serve to support partial or complete overdentures.

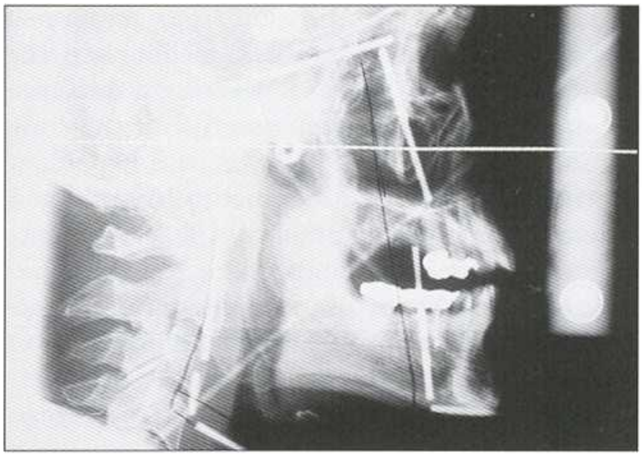


Fig 3-14 A simulator film demonstrates the anterior extension of the planned radiation fields.The anterior mandible and teeth appear to be located outside these fields. It may be possible to extract these teeth with minimal risk of osteoradionecrosis.

possible, a conservative approach is advised in regard to extraction of teeth after radiation. Extraction should only be considered after careful evaluation of all extenuating factors.

Localized periapical or periodontal infection can be managed conservatively with antibiotics, avoiding the immediate need for tooth removal. In situations involving single teeth, endodontics should be considered an option even when the tooth is considered nonrestorable. Following endodontic therapy, the badly decayed tooth crown is amputated to prevent irritation to the tongue or cheek and the exposed portion of the root canal is sealed with a permanent restoration (Fig 3-13). A tooth managed in this manner may serve no function but, more important, extraction is avoided.

Teeth located in areas not included in the radiation fields can be extracted safely. The anterior mandible is frequently excluded from radiation fields involving tumors located in the posterior portion of the oral cavity (Fig 3 14). The maxilla is also spared when the mandible or floor of the mouth is treated. When this possibility exists, the exact location of radiation fields must be determined prior to contemplating tooth removal. This information is available from a review of the patient’s radiation planning or simulation radiographs and/or after consultation with the responsible radiation therapist.

All too frequently, patients present who have need of multiple extractions. Until recently, acceptable management of these individuals was impossible. Today, with the use of hyperbaric oxygen, extensive oral surgery can be performed with a substantially diminished risk of necrosis (Marx, 1983). This procedure, however, is both expensive and time consuming, and its indiscriminate use should not be taken lightly. Because of a need for specialized equipment and well-trained personnel, this service is generally available only in major treatment centers.

Hyperbaric protocols involve a series of up to 20 “dives” before and after surgery in a small, sealed hyperbaric chamber. Each daily dive is 90 minutes long. The patient must be judged physically and psychologically capable of enduring these conditions. A thorough medical evaluation is a prerequisite for treatment.

Teeth are extracted following the initial 20 dives. Extractions arc generally performed in the operating room. Necessary surgery including extractions, alveolectomies, and tori removal is completed using atraumatic technique. The wounds are closed primarily. Following the surgical procedures, the patient returns for the completion of the second phase of the hyperbaric protocol. Additional dives may be necessary if wound healing is not complete. Clinical evidence indicates that using this procedure greatly reduces the risk of ORN and serves as an important tool in the management of the irradiated patient.

Osteoradionecrosis

Perhaps no subject has precipitated more animated discussion among dental oncologists than the cause and treatment of osteoradionecrosis (ORN) (Marx, 1986). It has been proposed in the past that ORN may result from trauma, exposure of radiated bone, and infection. Others have more recently advocated that the cause is related to the hypovascular, hypoccllular, and hypoxic conditions that exist in bone following radiation. Although trauma is thought by some to be a necessary initiating factor, numerous spontaneous cases of ORN have been reported. The type of radiation treatment employed, dosage, and tissue volume involved are also considered contributing factors. Clinical observation indicates ORN is more prevalent in the mandible than maxilla. This finding does not preclude the possibility of ORN developing in the maxilla, however. Improved radiation techniques and better cooperation between dentist and radiation oncologist have reduced the incidences of ORN from highs in the 1960s of 32% to about 9% today.

Patients may present with a complaint of varying degrees of discomfort. It is not uncommon, however, for individuals to be pain free and unaware that a problem exists. Clinical examination will generally reveal a soft tissue ulcer and an area of exposed bone. Any such wound should be viewed with suspicion, and the possibility of recurrent tumor must be ruled out.

Initial treatment should be conservative. The lesion is carefully cleansed and any small, sequestered bony fragments are carefully removed. Oral hygiene procedures are reviewed and the patient is asked to rinse frequently with dilute hydrogen peroxide or a salt and soda solution in an effort to keep the area moist and clean. Dentures, if present, are relieved over the affected area, and the patient may be cautioned to use the dentures only while eating. Conversely, it is thought by some that the denture serves to protect the wound and prevent further irritation from movements of the tongue. Soft plastic mouth guards have also been used as protective devices. Topical packing of the area with zinc oxide or various antibiotics has been recommended, but the use of these medications has not significantly improved clinical results.

Following initial treatment, the patient is seen at frequent intervals to evaluate the wound and reinforce home care procedures. When sequestra are evident, they may be judiciously removed and the area kept smooth to avoid irritation to surrounding tissues. Patients may report incidences of spontaneous sequestration. The wound may occasionally develop isolated, superimposed infection requiring the use of systemic antibiotics. The dentist must be aware that these relatively asymptomatic lesions will take an extended period of time to heal. Many radiologists do not identify such wounds as ORN until they have been present for a year.

Unfortunately, healing does not always occur with conservative treatment. The nonresponsivc affected area will enlarge with time, be subject to more frequent severe infection, and cause considerable pain. Pathologic fracture of the mandible may also be a finding. In these situations the patient is referred for hyperbaric oxygen therapy. After the initial series of dives, surgery, in most instances, is performed followed by a second series of dives. Substantial portions of the mandible may be removed leading to discontinuity defects. Mandibular reconstruction using microvascular surgical techniques may be necessary to restore patient function. Since its introduction as a treatment modality, hyperbaric oxygen has proven to be an effective method of managing the patient with ORN, solving a difficult, frustrating problem for both the dentist and radiation therapist.

Postradiation Prosthodontic Care

Patients treated with radiation suffer substantial changes to the oral mucosa and are often candidates for new complete or partial dentures. The oral soft tissue must be adequately healed before necessary prosthodontic procedures can be initiated. Since trauma caused by dentures may increase the potential risk of mucosal irritation and subsequent bone exposure, some have suggested waiting at least 6 months to a year before dentures are contemplated.

However, the insult to oral tissue as a result of radiation is dependent on a number of factors, and the severity of this insult is not the same for each individual. Patients who abuse alcohol or tobacco may need a substantially longer healing period than a nondrinker or nonsmoker. Delivered dosages, type of radiation employed, and size of areas radiated also play roles in soft tissue morbidity. Previous denture experience has been suggested to be an important determining factor as well, and patients who have had teeth removed immediately prior to radiation may benefit from an extended healing period.

An important issue to be considered is the social status of the patient. An elderly individual who is essentially confined to his home may not have a pressing immediate need for dentures, and a longer healing period may be appropriate. A young, socially active person or business executive, on the other hand, will demand that the denture-making process begin as soon as possible. Many patients have a need for closure of their therapeutic regimens and cancer problem. Knowing that prosthetic treatment is underway helps provide that closure. It is not suggested, however, that the dentist be influenced completely by patient demands, only that this factor be given thoughtful consideration.

In the final analysis, however, the clinician must after careful oral examination and review of all pertinent information decide on an appropriate time frame based on clinical experience and judgment. Clinical experience has demonstrated that dentures can be made for some individuals in a matter of 2 or 3 months following radiation with little complication. Conversely, some patients will never wear dentures successfully because of radiation effects. These issues are important topics for discussion prior to radiation to avoid subsequent misunderstandings.

Dentures should be carefully fabricated using conventional prosthodontic techniques. A wide variety of materials can be used when making impressions. The dentist may be well served by using a familiar technique, thereby avoiding the need for multiple remakes and an unpredictable result. It has been reported that plaster or zinc oxide may cause some discomfort related to tissue friability and the lack of saliva. Denture border extensions are developed with modeling plastic. This material must be properly tempered prior to placement in the mouth to prevent soft tissue irritation. Soft tissues are manipulated as gently as possible during the impression process. This is a convenient time to re-emphasize to the patient that denture retention may be compromised as a result of xerostomia.

Accurate temporary denture bases are fabricated and interocclusal records made in centric relation at a slightly closed vertical dimension. A closed vertical dimension is believed to place less stress on the alveolar ridges during function and parafunction and may also be an advantage in positioning the denture should trismus or fibrosis develop. Casts arc mounted on an articulator, and artificial teeth arc set. There does not appear to be any contraindication to the use of cither plastic or porcelain monoplane or anatomic teeth. The plastic, monoplane tooth is frequently the tooth of choice. A well-balanced, noninterfering occlusion is an absolute necessity regardless of the tooth form used.

An appointment to evaluate the waxed denture allows verification of interocclusal records and provides the patient an opportunity to satisfy esthetic considerations. The prostheses arc flasked and processed using heat-cured polymethyl methacrylate. Soft materials have been suggested for use as denture bases. In the past, these materials have offered little advantage over hard base materials because of their coarse surface and propensity for support of fungal growth.

Delivery procedures must be meticulously performed. Indicating paste is used to identify areas of excessive pressure. Denture borders should be carefully evaluated for areas of overextension, paying special attention to the retromy- lohyoid area. Remounting the dentures provides an opportunity for verifying the accuracy of inte- rocclusal records and developing a noninterfering occlusion. Upon completion of these procedures, the dentures are highly polished. Some clinicians advocate that the tissue-bearing surface of the denture also be polished to eliminate any surface roughness in an effort to minimize tissue irritation.

'fhe patient should be advised regarding the effect xerostomia and compromised mucosa have on the potential for prosthodontic success and should be cautioned to remove the dentures if any soreness or irritation develop and to sec the dentist as quickly as possible. The benefits of removing the dentures while asleep and maintaining appropriate oral hygiene procedures must be explained. Additionally, the patient must be seen at frequent intervals during the first few weeks following delivery of the dentures. Two appointments a week provide ample opportunity to intercept any problems that may develop.

Conclusion

The cancer patient who is to receive curative doses of radiation to the head and neck presents an interesting challenge for the dentist. An attempt has been made to review rationale for restorative, surgical, and prosthodontic procedures important in the dental management of the irradiated patient. Specific treatment regimens for morbidities associated with radiation effects have been discussed and the importance of patient compliance emphasized. Clinical procedures described are based on the dental literature and clinical experience gained while a member of the dental oncology staff at the University of Texas MD Anderson Cancer Center.

Dental management of the irradiated patient is a serious undertaking since the standard of care certainly has an effect on the patient’s quality of life. Dentists assuming the responsibility for treating this group must be willing to make a longterm commitment to each individual patient’s care. They must also have an understanding of basic radiation and dental oncology techniques and their own limitations but need not be trained specialists to justify involvement in management of this unique group of patients. In most instances routine dental treatment provided by the patient’s general dentist is encouraged and most welcome.

References

Brown L, Dreizen S, Daly T, et al. Interrelations of oral microorganisms, immunoglobulins, and dental caries following radiotherapy. J Dent Res 1978;57:882.

Dreizen S, Brown L, Daly T, et al. Prevention of xerostomia-related dental caries in irradiated cancer patients. J Dent Res 1977;56:99.

Flemming T. Oral tissue changes of radiation oncology and their management. Dent Clin North Am 1990;34:223.

Fox P, Van der Vcn P, Baum B, et al. Pilocarpine for the treatment of xerostomia associated with salivary gland dysfunction. Oral Surg 1986;6:243.

Jacob R. Management of xerostomia in the irradiated patient. Clin Plast Surg 1993;20:507.

Joyston-Bechal S. Prevention of dental diseases following radiotherapy and chemotherapy. Int Dent J 1992;5:46.

Kaanders J, Flemming T, Ang K, et al. Devices valuable in head and neck radiotherapy. Int J Radiat Oncol Biol Phys 1992;23:639.

Marx R. A new concept in the treatment of osteoradionecrosis. J Oral Maxillofac Surg 1983;46:351.

Marx R. Osteoradionecrosis: A new concept of its pathophysiology. J Oral Maxillofac Surg 1986;41:283.

National Institute of Health Consensus Development Conference. Oral Complications of Cancer Therapies: Diagnosis, Prevention, and Treatment. J Am Dent Assoc 1989; 119:179-183.

Scrimger J. Backscatter from high atomic number materials in high energy photon beams. Radiology I977;124:815.

Resin Bonding for Maxillofacial Prostheses

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The discovery by Rochette (1973) that dentists could indeed bond metal to the enamel surfaces of teeth with excellent stability in function brought a much-needed option for additive mouth preparation to the field of maxillofacial prosthetics. Rochette bridges, as they were known, were intended to replace single teeth or to serve as bonded splints for mobile teeth. They took the form of full lingual plating that had been perforated with a slight countersink on the outer surface of the perforation. These were bonded to place using the acid-etch bonding systems that were available at the time. Other metal bonding systems quickly followed as the materials and techniques improved with time. At the end of the 1970s, Wong et al (1982) bonded preformed cingulum rests to mandibular cuspids in a technique intended to eliminate the need for unesthetic incisal rests on those teeth. Not long after, a number of clinicians and investigators began to create rests and other contours with bonded resin alone. Twenty years of clinical evaluation has made these procedures routine in selected clinical situations.

The possibility of altering tooth contours with techniques that do not require full-veneer crown preparations has greatly reduced the cost of preparing the mouth for the complex removable partial dentures that are so often required in the field of maxillofacial prosthetics (Taylor et al, 1988).

Mouth Preparation

Mouth preparation, the creation of rest preparations and guiding planes with the occasional recontouring of a potential retentive area, has been primarily a subtractive procedure. For conventional partial dentures, this type of preparation is usually sufficient, but with the greater demands of obturators and other unconventional frameworks required for maxillofacial applications, additive mouth preparation is frequently required as well. In the past, this has always meant reliance on the full “surveyed” crown with the associated problems of marginal integrity, reduction of tooth structure, creation of esthetic veneers, and the re-establishment of occlusal surfaces. Using the technology of bonded contours, many of these problems can be eliminated without sacrificing the contours needed for ideal mouth preparation.

Additive mouth preparation is appropriate for the creation of rest seats; guide planes, whether primary or associated with minor connectors and indirect retainers; retentive contours for conventional clasping; and, in carefully selected clinical situations, bonded precision attachments (Taylor et al, 1988; Marinello et al, 1991). This type of mouth preparation is generally used along with the more conventional subtractive preparations that are more familiar. Since the bonded contour can be either composite resin or fabricated of metal that is microetched and then bonded to place, it is obvious that the methods of creating these contours are quite different.

Bonded Composite Resin Contours

In its simplest form, the all-composite resin contour is formed by the standard procedures necessary lor all resin-bonding applications, ie, isolation, cleansing of the enamel surface, acid etching, washing and drying, and the placement of an appropriate resin in a quantity that will ensure an excess of material beyond the desired form of the restoration. Once the resin has polymerized, it is recontoured to the desired form using subtractive mouth preparation and polished. For a simple cingulum rest on a mandibular cuspid, this approach is more than adequate, but for more complex contours, especially multiple guide planes, subtractive mouth preparation of a bulk of composite in the mouth makes the creation of ideal contours unlikely.

To create multiple parallel guide planes, the kind that are so often needed, for example, on the lingual surfaces of maxillary molars to isolate the path of insertion and removal of a hemimaxillec- tomy obturator and thereby reduce the requirement for excessive retention through clasp arms, a template of the desired contours must first be created (Fig 4-1).

A diagnostic cast, with the areas of desired additive recontouring clearly marked, is waxed and milled on a dental surveyor to create the parallel surfaces of the guide planes (Figs 4-2 to 4-5). Once these contours are fully established, the cast is duplicated in stone and a vacuum-formed clear template is made of the teeth to be modified (Fig 4- 6). Since a stiff template will be required to force the composite to place before light curing, a thick vacuum disk should be chosen (2 or 3 mm). The template is trimmed to retain sufficient occlusal or palatal stops to allow for positive repositioning. When the isolation and etching steps have been completed, a careful estimate is made of the amount of composite resin needed to create the desired form, using the waxed-up diagnostic cast as a reference, and this amount placed in the appropriate sections of the template. The template is forced to place and, when fully seated, the resin is light cured through the clear template. When multiple surfaces are involved, it is appropriate to create only a few surfaces at a time, reusing the same template each time. Removal of excess composite at the margins is difficult; however, since the contours are always supragingival, careful placement of the etching acid should reduce clean-up time. Resins of a slightly darker or lighter color than the tooth surface being bonded can be used to make identification of excess easier but, since the contours will be covered by the framework, the color difference should not be objectionable (Fig 4-7).

This procedure is not guaranteed to produce the ideal milled guide planes that were established in diagnostic waxing since its accuracy is dependent upon a careful estimate of the material to be added and the success with which the template is fully seated before curing. The completed bonded restorations must always be verified with a check cast made from an alginate impression and poured in fast-setting stone. The resultant cast is placed upon the dental surveyor and the parallelism checked. Often some subtractive preparation of the composite is required. Occasionally the template will have been underfilled and additional material must be added to complete the contour, usually in small amounts.

An identical procedure is used when multiple retentive contours are needed. Again, it is of some value to use a composite of a slight shade mismatch so that the added material can be distinguished from the tooth enamel when subtractive preparation is needed. The choice of a resin for these procedures has not been clearly established. The heavily filled composites seem to be the material of choice, but there is some indication that these materials will erode clasp arms in time. How they perform as guiding plane surfaces has never been fully established, but a recent study indicated that a glass filler of 63% by weight with 25% macrofiller reinforcement showed the least wear with repeated insertions and removals of guide plane surfaces (Nabadalung et al, 1997). It would appear from clinical experience that the choice of resins for rest seats is immaterial since so little friction seems to occur. Wear studies of

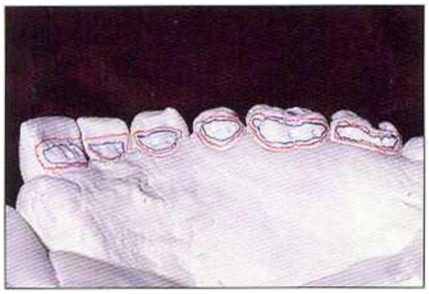


Fig 4-1 Cingulum and lingual guide planes outlined on diagnostic cast for a hemimaxillectomy obturator.

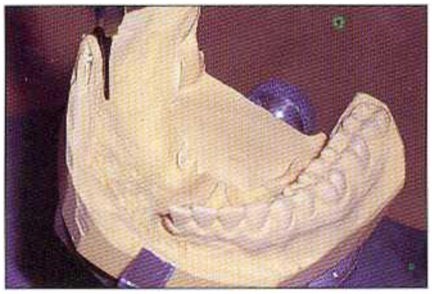


Fig 4-2 Master cast for a hemimandibu- lar restoration mounted in the dental surveyor.

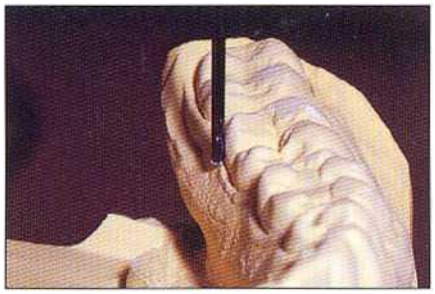
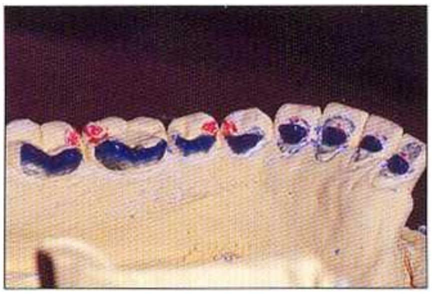


Fig 4-3 Analyzing rod indicating lack of parallel lingual guide plane surfaces.



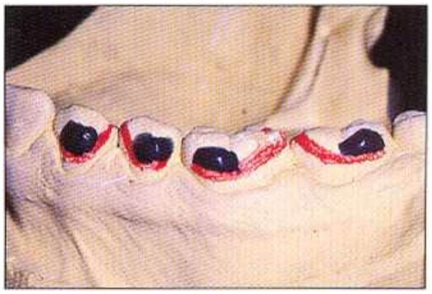
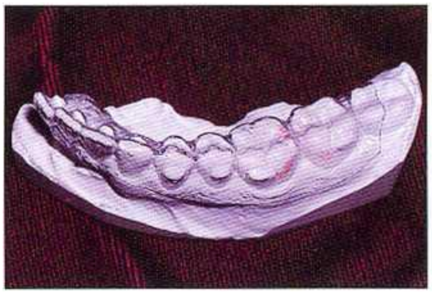


Fig 4-4 *(left)* Diagnostic waxup for lingual guide planes to be made in bonded composite resin.

Fig 4-5 *(right)* Labial heights of contour waxed for circumferential clasp arms to be created in bonded composite resin.



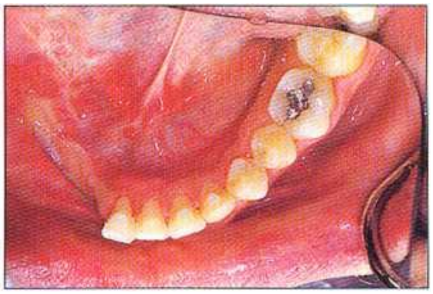


Fig 4-6 *(left)* Vacuum-formed template on duplicate of waxed diagnostic cast.

Fig 4-7 *(right)* Completed composite guide planes and retentive contours.

resins used for retentive contours showed only 50 pm of wear of the composite in simulated 3-year bench trials of insertion and removal (Hebei ct al, 1984).

Undercut areas for retentive clasps, beginning at the start of the terminal third of the active clasp length, are normally in the range of .250 to .350 mm. The height of contour necessary to produce this undercut must be evaluated relative to the intended path of insertion. It may appear, on severely tilted teeth, that an undercut has been established, but it may only be in relation to the long axis of the individual tooth, not to the overall path that the framework will take when inserted and removed. When planning retentive heights of contour, it is important to remember that their oc- clusogingival position must allow the clasp to be at least 1 mm above the gingival tissue when seated. The timing of the undercut must also be considered in the shaping of the retentive contours. The transition of the height of contour to the undercut depth can be either gentle or abrupt,

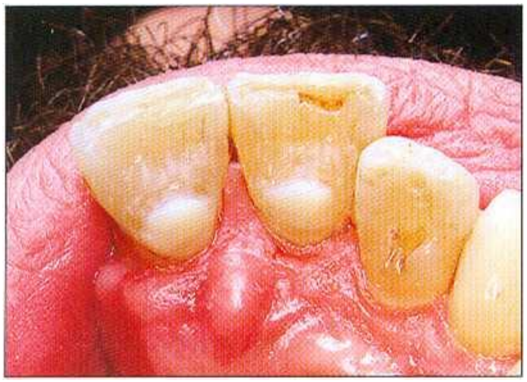


Fig 4-8 Composite resin cingulum rests placed on the central incisors to prepare them as abutments for an obturator prosthesis.

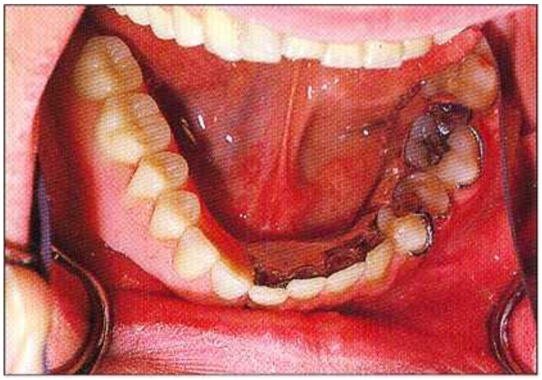


Fig 4-9 Completed hemimandibular reconstruction using composite guide planes, rests, and retentive contours.

depending on the type of retention desired. When these contours are in enamel or metal/porcelain, either can be used without problems, but with composite contours, the more gentle transition may reduce any tendency to chip the composite by the clasp arm as it contacts the contour.

The great advantage for the bonded composite resin contour is that if and when wear occurs, retrofitting of the framework is not terribly difficult. If the frame has been designed so that there is an access hole below the cingulum rest, additional material can be added and light cured, at least to a firm consistency that would allow removal of the prosthesis before additional curing (Fig 4-8). If the area to be retrofitted is completely covered by metal or denture base material, a chemically cured composite resin will need to be used, which requires much more care so that the prosthesis is not locked on the teeth. The metal guide plates are made to a blocked-out master cast so they can be expected to be parallel and flat. Resin, retrofitted against these plates, is unlikely to enter undercuts in the metal of such a size as to create a lock that will not release on removal of the framework (Fig 4-9).

Metal-Bonded Contours

It is obvious that metal contours are far more versatile than all resin contours. They offer the opportunity to actually mill the guide plane surfaces in the same manner as surveyed crowns are milled. Their wear resistance is clearly greater than when these surfaces are made of composite, and they have the added advantage of being bonded with only a very thin layer of composite luting agent. The bond strengths of well-made composite luting agents are known and the risk of debonding based upon the loads placed on the resin by the prosthesis is small, but when composite resin is used in bulk, the potential for cohesive fracture within the material itself exists. This problem is most likely to arise when the teeth supporting all composite contours are mobile. Heavy loads are apt to create a fracture through the body of the restoration as the tooth moves in function and the rest is held in position by the fit of the framework. When the contour is fabricated of metal, fracture is much less likely and the bond to the tooth remains very strong.

If metal contours are to be used with contours created by subtractive mouth preparation, the subtractive preparation should always be done first. It is far easier to create contours in metal that are parallel to existing tooth surfaces than to fry to shape teeth with a handpiece to match the metal contours already bonded in place. In all instances of complex mouth preparation of either metal or resin, final contours must be created on the diagnostic cast first. Once the ideal contours are established on the diagnostic cast using the

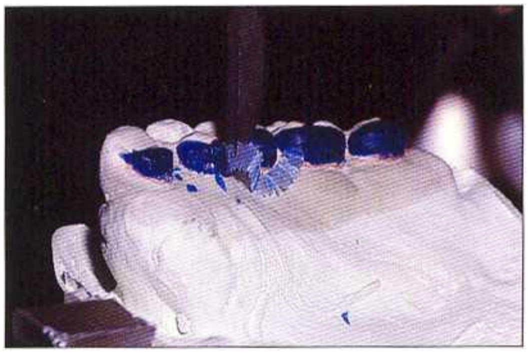


Fig 4-10 Waxups for cast guide planes being made parallel with blade in dental surveyor.

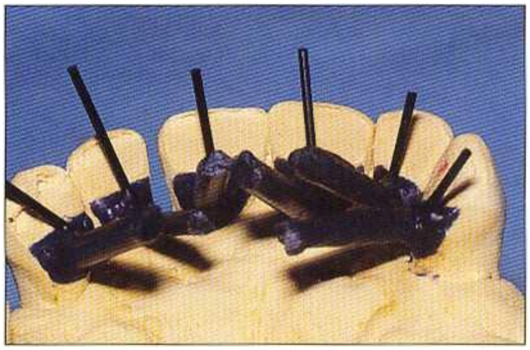


Fig 4-11 Multiple waxups for cingulum rests with sprues and plastic bristles from a toothbrush added as handles of completed castings.

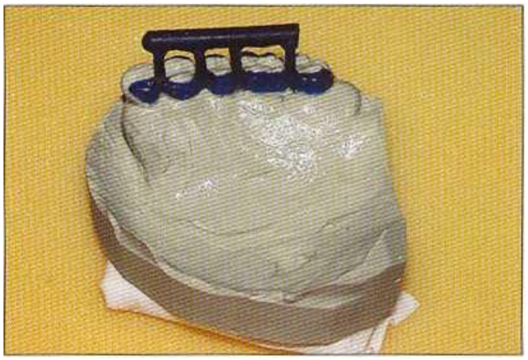


Fig 4-12 Spruing for multiple guide planes to be cast in one piece.

dental surveyor, decisions on enamel recontouring to support the castings are made. These generally take the form of slight ledges in the enamel that will serve as locators as well as vertical stops for the metal restoration. For those situations where there will be a great deal of lateral and rotational force placed on the metal contours, additional preparation is required (primarily for bonded precision attachments). Axial surfaces are paralleled in the lingual enamel and microgrooves arc placed in the enamel to resist rotational debonding. These grooves are placed parallel to the path of insertion and the lingual surface.

A final impression is then made with an impression material that is compatible with the refractory material in which it will be poured. Since the alloys used for bonded contours are Ni-Cr, a high-heat, phosphate-bonded investment is chosen. These investments are generally compatible with silicone impression materials. The metal contours are waxed directly onto the refractory cast and should be duplicates of those created in the diagnostic waxup (Fig 4-10). Because the individual cast units can be quite small, such as for a cingulum rest, a plastic toothbrush bristle is added to the incisal/occlusal areas to serve as a handling device until the unit has been bonded in place (Fig 4-11). It is then removed and the metal in that area polished in the mouth. Sprues are attached to the axial surfaces and the individual units are cut from the cast with a die saw. The sprues are assembled into castable units and placed in the appropriate casting rings (Fig 4-12). Additional investment material is then mixed and added to the ring to complete the investment process.

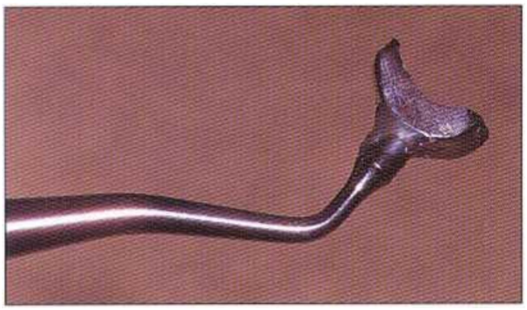
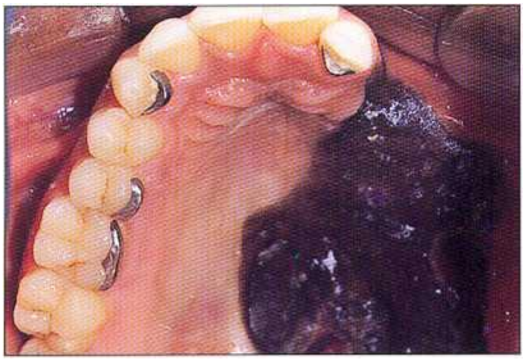


Fig 4-13 Etched casting attached to an amalgam plugger with sticky wax. Small size of casting prohibits it being carried into the mouth by hand.



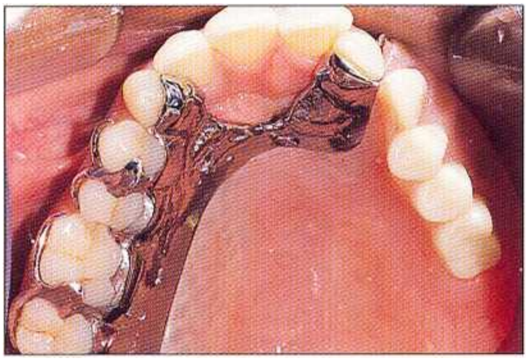
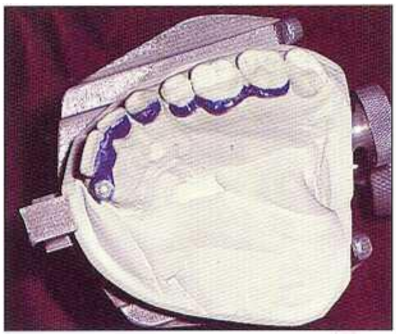


Fig 4-14a Ungual guide planes and cingulum **Fig4-14b** Definitive obturator prosthesis in position, rests bonded to place.

Burnout and casting are done as if the units were removable partial denture frameworks. In general, the alloy is 70-16 Ni-Cr. Rexillium (Jeneric/Pentron, Wallingford, CT), a 76% Ni, 14% CR alloy with beryllium (1.8%) that casts at 2450°F (1345°C), is often used. Finishing and polishing arc also done as though the castings were partial denture frameworks. The castings can be attached to a second pour cast of the final impression with small amounts of cyanoacrylate so that their guide plane surfaces can be machine milled to parallelism.

Metal contours can be prepared for bonding in a number of ways. They can be microblasted with abrasives, electronically or chemically etched, or treated with some combination of these methods as preferred by the clinician (Fig 4-13). It does not seem to make a difference clinically which method is used as long as the metal is not contaminated after preparation. As with all bonded metal surfaces, chemically activated composites must be used since light curing will not be possible. Manufacturer’s directions must be carefully followed to ensure maximum bond strength. Unfortunately, the chemically cured composites have a short shelf life and expiration dates must be checked when these products are only used occasionally (Fig 4-14).



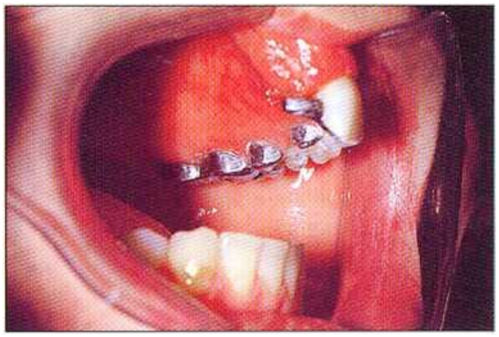


Fig 4-15 Waxup of multiple guide Fig 4-16 CEKA attachment and guide planes planes with CEKA attachment on bonded in place, central incisor.

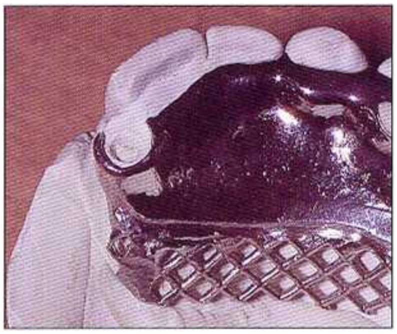


Fig 4-17 Obturator casting seated on master cast. The lingual plate of the removable casting rests on solid rest seats placed in the anterior bonded castings.

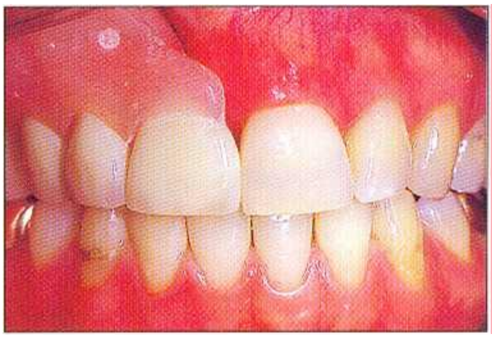


Fig 4-18 Completed attachment-retained obturator in place. Conventional posterior embrasure clasps, combined with the parallel guide plane surfaces on all posterior teeth, carry the bulk of the retentive requirement, allowing minimal loading of the esthetic attachment.

Precision and Semiprecision Attachments

True indications for precision and semiprecision attachments for the maxillofacial patient are not as obvious as for a conventional patient. The attachment only takes the place of a visible clasp arm. All other aspects of partial denture retention and stability are more properly done with guide planes and plates. For most rehabilitative situations, the creation of ideal esthetics may not be as important as the obturation of a large defect, for example. There are situations in which an attachment may be indicated rather than a clasp, regardless of esthetics. The most obvious of these is when a central or lateral incisor is the terminal abutment adjacent to a large defect. The contours of these anterior teeth often do not lend themselves to conventional clasping, so the addition of a bonded attachment on the prime abutment may provide the best retention possible for that component of the prosthesis (Fig 4-15). Attachments that permit some measure of rotational freedom are most appropriately selected since movement of the prosthesis is certain to occur. A number of different attachments have been used successfully in these situations. When using a bonded attachment, the life of the attachment can be increased if the attachment does not become the rest as well as the retentive component (Fig 4-16). Milled rest seats developed on the casting that holds the attachment allow the stress to be transferred to the long axis of the abutment rather than to the cantilevered extracoronal attachment (Figs 4-17 and 4-18).

Problems Associated with Bonded Contours

The maxillofacial patient, even though in desperate need of the control that comes from ideal mouth preparation through bonding, may well be the most difficult patient to treat using these techniques. Trismus or fibrosis will often limit access to the mouth in such a way that the indirect bonding approach is not possible. It may also compromise the isolation of the teeth for the bonding procedure, resulting in early failure through debonding of contaminated resin. The effects of radiation on the enamel surfaces may alter the microetching and the resultant bond strength.

As with all cemented or bonded restorations, loss of attachment is always a possibility. For the maxillofacial prosthetic patient, the clinical situation and the extent of the treatment needed makes failure of components and materials even more likely than in ordinary situations. The need to apply resin-bonded components in areas not usually seen, such as on the lingual or palatal aspects of posterior teeth, combined with limited mouth opening often precludes the use of rubber dam for component placement. While one cannot advocate placement of resin-bonded components without ideal isolation, to choose not to use the resin-bonded concept because rubber dam cannot be used is condemning the patient to either more aggressive dental techniques or the possibility of a compromised result of treatment. In the few situations in our experience where resin-bonded components have lost adhesion, a repair or modification of the guiding surface and/or the prosthesis has been successful. No prostheses have been rendered unusable because ofloss of a resin-bonded component.

'Flic reparability of all resin-bonded components has already been briefly discussed, but the technique we have found to be successful warrants description. If a composite resin-bonded component or a metal resin-bonded component is lost, it is quite easy to retrofit the prosthesis directly in the mouth. If a metal component is lost, it is best to replace it with a composite component due to the difficulty of accurately repositioning the metal component on the tooth (Fig 4 19). An exception would be where a precision or semiprecision attachment has come loose. In that case, the component can be cleaned, reetched, attached to the prosthesis, and then carried to the mouth for rebonding. For replacing any other component, the area of the prosthesis corresponding to the lost component should be smoothed and polished to reduce the possibility of locking the metal framework onto the tooth being bonded (Fig 4-20). To further decrease the possibility of locking the prosthesis in place, the surface to be refitted is sprayed liberally with a silicone release agent (Fig 4-21). This is the method of choice if the component to be replaced is in an area that can be light cured (or dual cured) with the prosthesis in place. If light curing is not possible, a chemically cured composite should be used (Fig 4-22).

When cingulum rests are being replaced beneath plated framework major connectors it is difficult to gain access for light curing unless transillumination from the facial aspect is used. If guide planes are being replaced as seen in Fig 4-19, the framework may be seated completely and the composite resin added while the framework is in place. With this method it is likely that voids will be incorporated into the resin that require secondary additions. Whatever the method used, it is critical to ensure that the composite addition docs not prevent removal of the framework. One should realize that repair or direct application of composite resin beneath a framework will likely cause the framework to bind on the tooth that the resin has been added to. This is because cast removable partial denture frameworks are fabricated against stone casts and do not fit the abutment teeth perfectly (if at all). When a framework is retrofitted with a composite resin component, the framework will be in intimate contact with the resin addition unless it is adjusted. Care should be exercised in evaluating physiological movement of the framework to determine whether the abutment tooth appears to be taking too much ofthe load of function. If this appears to be the case, one should consider lightly adjusting the composite resin addition with a fine-grit disk or similar abrasive agent.

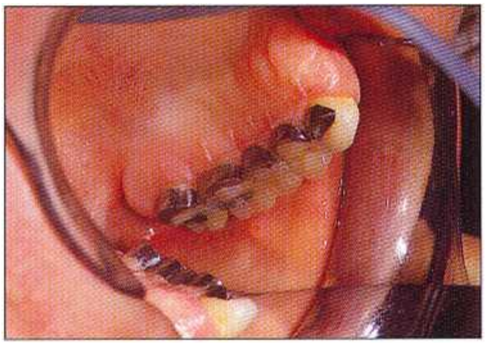


Fig 4-19a Metal guide planes and cingulum rests in an extremely difficult situation in which the remaining teeth are in only one linear dimension and there is no palatal defect that can be used to augment retention. The loading of these components is anticipated to be very heavy.

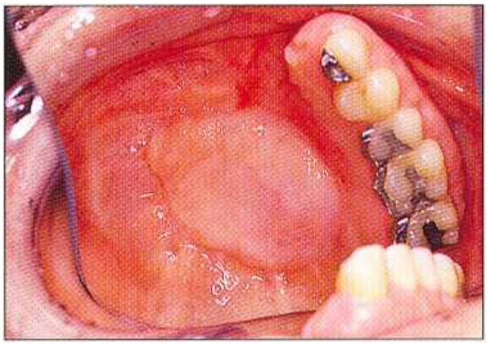


Fig 4-19b A resin-bonded guide plane has been lost and requires replacement to maximize the distribution of load from the prosthesis and to occlude the space left between the tooth and the removable framework after loss of the metal guide plane.

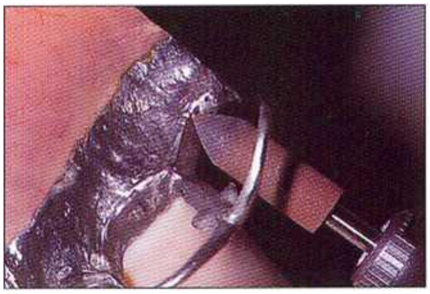


Fig 4-20 The guide plate surface of a removable framework is polished using rubber wheels to minimize the risk of locking the framework onto the tooth following addition of composite resin as a repair procedure.

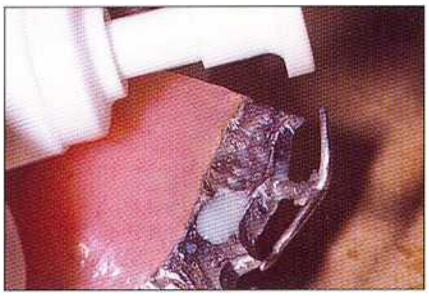


Fig 4-21 After polishing, the guide plate surface is sprayed with a silicone release agent or with petrolatum to reduce the likelihood of locking the framework on the abutment tooth.

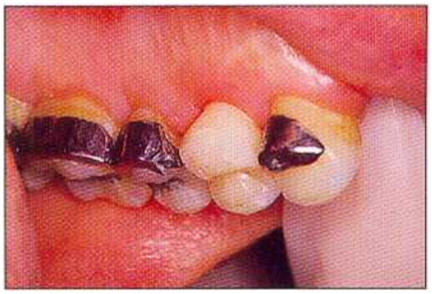


Fig 4-22 Composite resin guide plane placed as a repair to replace lost metal guide plane for patient seen in Figs 4- 19a and 4-19b.

Summary

This chapter has described the techniques in volved in using resin-bonded components to assist in the retention, support, and stabilization of maxillofacial prostheses. The benefits and problems encountered with the use of resin-bonded components used to modify contours on remaining natural teeth to serve as abutments for maxillofacial prostheses were also described. Bonded contours for ideal mouth preparation are worth considering for many patients, as the only alternatives are the full-veneer, surveyed crown or a prosthesis with less than adequate support, stability, or retention.

References

Hcbcl K, Grciser G, Featherstone J. Abrasion of enamel and composite resin by removable partial denture clasps. J Prosthet Dent 1984;52:389.

Marinello C, Scharer P, Mayenberg K. Resin-bonded etched castings with extracoronal attachments for removable partial dentures. 1 Prosthet Dent 1991;66:52.

Nabadalung D, Nicholls J, Brudvik J. Frictional resistance of removable partial dentures with retrofitted resin composite guide planes, hit) Prosthodont 1997; 10:116.

llochette A. Vissagc-collagc cn odonto stomatologic. Paris: J illicit Prclat, 1973.

Taylor T, Gerrow J, Brudvik J. Resin-bonded components for maxillofacial prosthesis construction: A clinical trial . J Prosthet Dent 1988;59:334.

Wong R, Nicholls J, Smith D. Kvaluation of prefabricated lingual rest seats for removable partial dentures. J Prosthet Dent I982;48:521.

Nasoalveolar Molding in Early Management of Cleft Lip and Palate

CHAPTER 5

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While advances in reconstructive surgery have significantly improved the quality of repair for clefts of the lip, alveolus, and palate, surgery alone cannot correct all aspects of the cleft detect. The bilateral cleft lip and palate defect is a particularly challenging congenital anomaly (Fig 5-1). When standard surgical approaches are used to repair deficiencies in the lip, columella, and philtrum, the result is often severe scarring of the nasolabial complex. Similarly, the unilateral cleft lip and palate defect, although not often as severe as the bilateral defect, will yield a less than ideal esthetic result when addressed only through a surgical correction (Fig 5-2). Multiple additional surgeries are then often required to improve the initial surgical repairs and to correct deficiencies that result from the surgery itself.

The basic goal of any approach to cleft lip, alveolus, and palate repair, whether for the unilateral or the bilateral anomaly, is to restore normal anatomy. Ideally, deficient tissues should be expanded and malpositioned structures should be repositioned prior to surgical correction. This provides the foundation for a less invasive surgical repair. Historically, the use of presurgical infant orthopedic (PSTO) appliances, or molding plate therapy, has aided significantly in reducing the size of clefts of the alveolus and hard palate prior to surgery. Since its introduction by McNeil in 1950, various techniques for molding the intraoral alveolar segments closer together in unilateral and bilateral cleft situations have been described (Mylin, 1968; Latham, 1980). Although controversy surrounds the use of PSIO devices in conjunction with various surgical protocols when employed to move only the alveolar segments closer together, this chapter describes a new approach of presurgical nasoalveolar molding (PNAM) therapy developed at the Institute of Reconstructive Plastic Surgery at New York University Medical Center. PNAM includes not only the reduction of the size of the intraoral alveolar cleft through the molding of the bony segments, but also the active molding and positioning of the surrounding soft tissues affected by the cleft, including the deformed soft tissue and cartilage in the cleft nose. This is accomplished through the use of a nasal stent that is based on the labial flange of a conventional oral molding plate and enters the nasal aperture (Figs 5-3 and 5-4). The stent provides support and gives shape to the nasal dome and alar cartilages. Presurgical nasoalveolar molding may be successfully employed in the early management of both the unilateral and bilateral cleft anomalies in newborns. In the bilateral cleft condition, presurgical nasoalveolar molding may be combined with col- umellar elongation to create a “neocolumella” through a nonsurgical approach (Fig 5-5). When there is a close coordination between the presur-

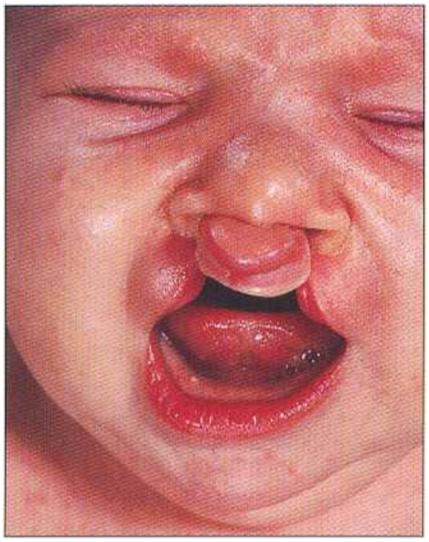


Fig 5-la Newborn with bilateral cleft lip and alveolus with nasal deformity, pretreatment. The alar cartilages have failed to migrate up into the nasal tip. The result is an absent columella.

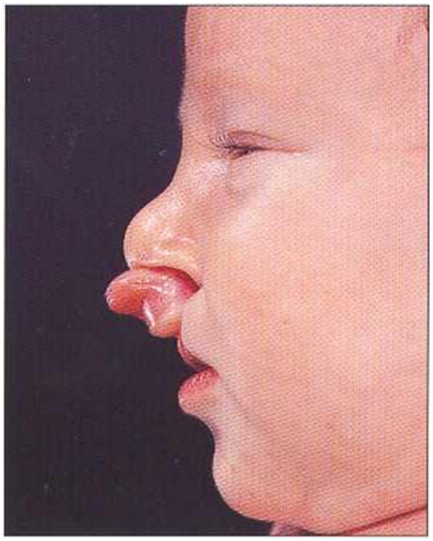


Fig 5-lb The cartilages are positioned along the alar margins as seen in the flared alae. The premaxilla is rotated upward and out of the maxillary arch.

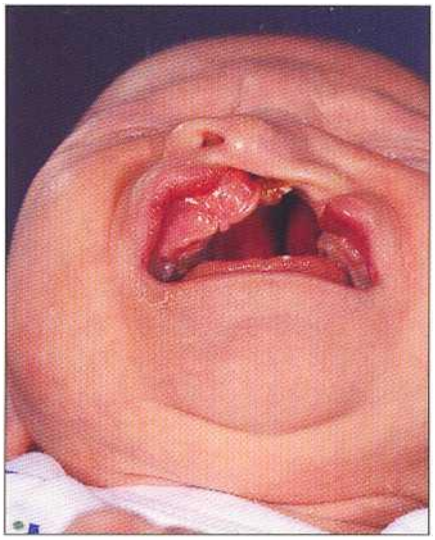


Fig 5-2 Newborn with unilateral cleft lip, alveolus, and palate with nasal deformity, pretreatment. The nasal lower lateral cartilage on the cleft side is depressed, concave, and separated from the cartilage on the unaffected side.

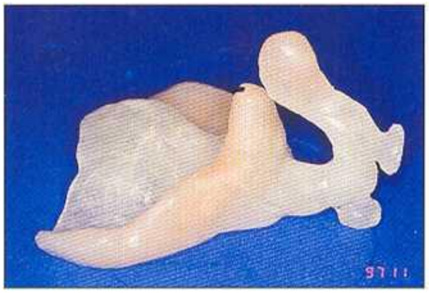


Fig 5-3 Unilateral nasoalveolar molding prosthesis (intraoral molding appliance with nasal stent) (lateral view).

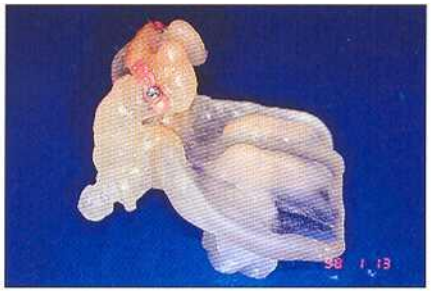


Fig 5-4 Bilateral nasoalveolar molding prosthesis (intraoral molding appliance with paired nasal stents) (lateral view).

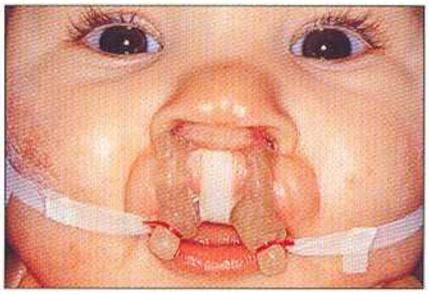


Fig 5-5 The bilateral nasoalveolar molding and columellar elongation appliance in place with retentive tapes and elastics.

gical phase of treatment and the surgical method employed, these new techniques greatly improve upon the results usually produced through traditional PSIO. The result is an overall improvement in the esthetics of the nasolabial complex in both the unilateral and bilateral cleft conditions while minimizing the extent of surgery and the overall number of surgical procedures.

Clinical Method for Correction of the Unilateral Oronasal Cleft Deformity

As soon after birth as possible, the infant is evaluated by all members of the interdisciplinary cleft palate team. The cleft defect is examined for the presence of natal teeth, a Simonart band, unusual undercuts, or other tissue abnormalities. If a tooth is present near the cleft, it is often removed,

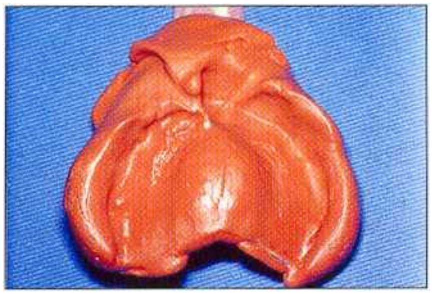
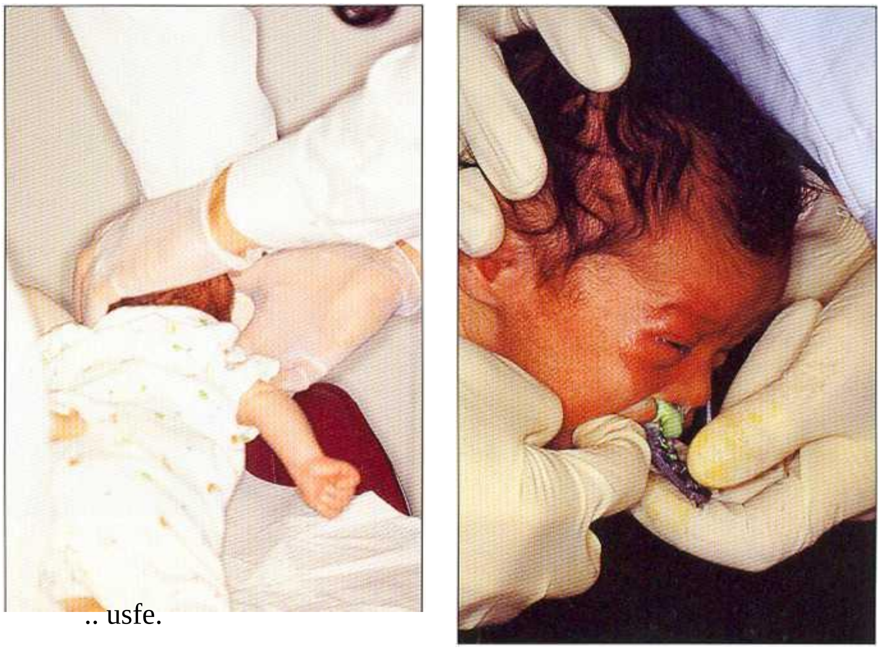


Fig 5-6 Representative high-consistency elastomeric impression of the infant unilateral cleft defect in custom tray. Excess material posterior to tray must be avoided.



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Figs 5-7a and 5-7b *(right)* Technique for obtaining intraoral impression of cleft deformity in the newborn infant. Baby is held face-down to prevent aspiration if the baby regurgitates stomach contents.

as its presence will complicate healing during the surgical phase of treatment. The tooth is removed with a pediatric forceps after administering a small amount of local anesthetic.

Following evaluation and after a thorough explanation of the procedure and treatment goals to the parents, an impression of the intraoral cleft defect is made using an elastomeric material in an acrylic tray (Fig 5-6). The impression material of choice has been very high-consistency Reprosil (LD Caulk/Dentsply, Milford, DE). A wash of light body material is not used because the registration of minute tissue detail is not necessary. The setting time of this material can be easily controlled. Working in conjunction with the manufacturer, we have obtained consistent results with the fastest setting time using a ratio of two parts base material mixed with one part catalyst. The polyvinylsiloxane elastomeric materials such as Reprosil also exhibit excellent tear strength and can yield two or more casts without significant distortion. Irreversible hydrocolloid is never used due to its poor tear strength and the possibility of having small pieces break free from the impression and occlude nasal passages or branches of the respiratory tree. Additionally, irreversible hydrocolloid does not reliably provide two casts from a single impression.

The impression is obtained with the infant fully awake and without any anesthesia. The infant is held face down to prevent the possible aspiration of regurgitated stomach contents. One person cradles the infant securely around the chest and torso, supporting the head and neck, while another obtains the impression (Fig 5-7). High-volume evacuation is also ready at all times also in case of regurgitation of the stomach contents. The head is gently held in a slightly upright position during the impression procedure. A properly sized and fitted infant acrylic tray is used in delivering the impression material. Care is taken to ensure that the material has registered the border regions of the maxilla and premaxilla as well as the cleft region. It is not necessary, however, to impress deeply into the nasal cavity in the cleft, reducing the risk of traumatizing the nasal tissues. Excess impression material posterior to the end of the tray must not block the airway, as infants arc obligate nasal breathers. The infant should be able to cry during the impression-making procedure. If no crying is heard, the airway is blocked. A finger motion should be used to clear any impression material posterior to the tray and to prevent the infant front closing down on the tray, which also will compromise the airway. At our institution, all impressions of clefts in infants

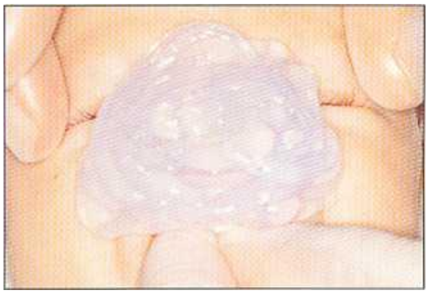


Fig 5-8 Clear polyvinylsiloxane impression of the nasal deformity may be obtained to study pre- and postmolding nasal form.The nasal impression is not used in fabricating the nasal stent.

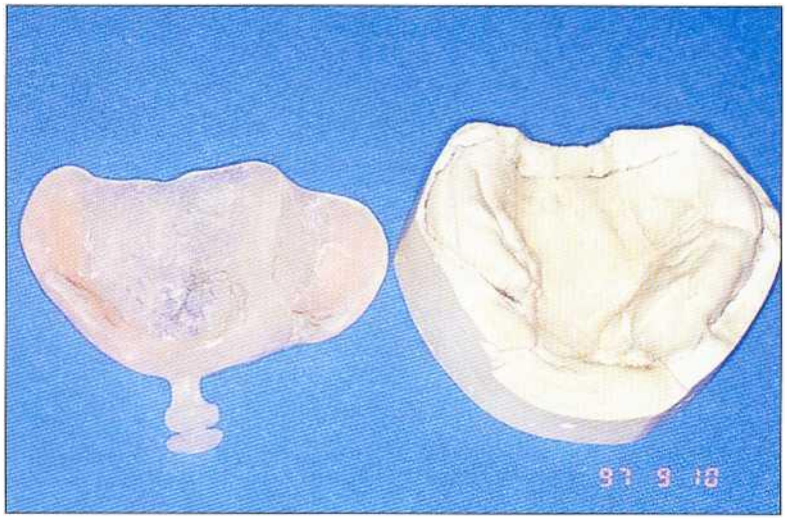


Fig 5-9 *(right)* Maxillary stone cast used to fabricate a custom acrylic unilateral intraoral molding appliance.

arc made in the hospital setting with a surgeon present as part of the impression team. The hospital setting also allows a rapid response by an airway team should there be an airway emergency.

An impression of the nasal region is not necessary but may be helpful in comparing the pre- and postorthopedic molding results. A nasal impression may be obtained using clear polyvinyl- si I oxanc (Mcmosil CD, Heraeus Kulzer, South Bend, IN) expressed directly onto the cleft nose from the radix to the lip (Fig 5-8). Cotton plugs attached to dental floss are used to prevent material from lodging deep in the nostrils. Great care must be used in obtaining a nasal impression of the cleft infant. The nasal impression is not used in fabricating the nasal stent portion of the nasoalveolar molding device.

When the material has fully set (approximately 2 minutes intraorally), the impression is removed and inspected to ensure all desired landmarks have been captured. An acceptable impression is then carefully poured in modified dental stone (Silky-Rock, Modern Materials, St Louis, MO) and the cast recovered. A second cast is poured and recovered. One cast will serve as the working cast upon which the intraoral molding plate will be fabricated while the second cast will become part of the patient's permanent record.

'fhe recovered working cast is trimmed and inspected. The size of the defect at the level of the alveolus is measured on the cast and recorded in the patient's chart. The cleft region of the palate and alveolus may be filled in with wax to approximate the contour and topography of an intact arch prior to the fabrication of the oral portion of the molding appliance. The modified cast is then lubricated with a thin layer of petroleum jelly. A soft, resilient, slowly polymerizing acrylic (Mvcrson Permasoft, Austcnal, Chicago, IT) may be applied to the undercut regions on the cast. Fhe remainder of the oral molding plate is fabricated from clear methyl methacrylate orthodontic resin (LD Caulk/Dcntsply) using one of many acceptable techniques. Ideally, the oral molding should be waxed from two layers of baseplate wax and then packed and lab processed (Fig 5-9). If time does not allow for the heat- processed method, several alternatives may be considered. The “sprinkle” method, where small controlled portions of powder and liquid are incrementally added to the cast, is very effective, although the resulting acrylic plate exhibits multiple porosities and is cloudy. The preferred method is to mix the resin to a thick consistency and load it into a small SurgiDent DispOral syringe (Mile, South Bend, IN). This mix is then expressed onto the cast in lines until the entire cast is covered. The material is then carefully worked to ensure uniform coverage of the cast with acrylic. Before the material begins to set, the cast is placed in a pressure pot at approximately 32 psi with I98°F water for 10 minutes until the methyl methacrylate is fully cured. This provides a bubble-free, clear acrylic oral molding plate with a uniform thickness in a relatively short period of time. This method also reduces the amount of residual free monomer in the resin, 'file molding appliance is trimmed to ensure that all tissue borders arc smooth, while the oral portion that will be in contact with the dorsum of the tongue is given a highly polished finish.

At the delivery appointment, the oral molding appliance is carefully fitted in the infant's oral cavity. Initial attention is given to the retention of the appliance. A well-adapted and properly constructed molding plate will usually be fairly self- retentive. If the appliance fails to be retentive upon insertion, the border regions and particularly the posterior border should be evaluated and adjusted. The appliance must not fit too tightly, however, as it is primarily retained through extraoral facial tapes and elastics. Additionally, no acrylic material should project into the cleft areas, as this material will ultimately block the intended movement of the alveolar segments into their desired final presurgical positions. After initially inserting the oral molding appliance, the baby must be observed for several minutes while the clinician stabilizes the appliance against the palate with a gloved index finger. The infant must be able to easily suckle without gagging or struggling. As the clinician's finger stabilizes the plate, it will also enable one to assess how well the infant is able to suckle with the new device. If gagging is noted, the posterior extent of the appliance should be reduced. In addition, a compromised tongue space may also compromise suckling; therefore, the thickness of the palatal portion of the appliance should be checked and reduced if necessary.

'l'he tissue surface of the appliance is also modified at the initial insertion appointment to begin the molding of the greater and lesser alveolar segments on either side of the cleft. This is achieved through the selective removal of acrylic from the region into which one desires the alveolar bone to move (Fig 5-10a). At the same time, Permasoft is added to line the appliance to a thickness of approximately 1 to 1.5 mm in the region from which one desires the bone to be reduced or moved (Figs 5-10b and 5-11). The usual movement is to direct the greater segment inward toward the cleft by adding Permasoft to the inner surface of the labial aspect of the alveolus portion of the appliance while reducing the acrylic from the palatal aspect of the appliance. The alteration of the lesser segment of the alveolus is the converse of that applied to the greater segment. The usual desired movement is to direct the lesser segment outward from the cleft. To achieve this, the acrylic is selectively removed from the inner labial aspect of the lesser segment of the alveolus (approximately 1 to 1.5 mm) while adding an equal amount of resilient soft liner on the palatal aspect of the alveolus in the lesser segment. These minor adjustments are made weekly. The degree and location of the modification will require a careful consideration of each individual cleft situation. The ultimate goal of this sequential addition and selective grinding away of material is to reduce the size of the cleft gap and to have the two segments of alveolus contact with the configuration of a proper maxillary alveolar arch form.

Also at the initial insertion appointment for the unilateral cleft patient, an extraoral retentive button is developed with clear orthodontic resin at the site of the cleft in the lip. This retentive button serves to facilitate both the positive seating of the appliance to the palatal tissues and to secure the retentive lip tapes and elastic bands. The retentive button should be positioned facing downward on the labial flange at a 45-degree angle relative to the occlusal plane, allowing for clearance of the upper and lower lips. Its length must also not prevent the mother from feeding the infant, as the device will need to be worn continuously to be effective. Pacifiers may need to be modified as well so they do not interfere with the retentive button and molding plate.

Proper retentive taping between appointments is crucial if the appliance is to be maximally effective (Fig 5-12). A broader base tape of Suture-Strip (0.5X1.5 inch) (Genetic Laboratories Wound Care, St Paul, MN) is first applied to the infant's cheeks lateral and superior to the commissures. These base tapes will serve to anchor the thinner (0.25X4 inch) Suture-Strips that are

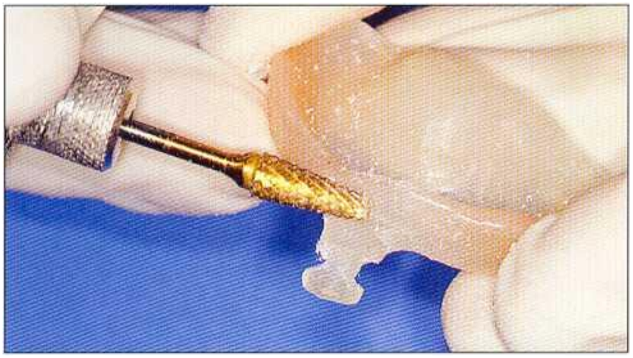


Fig 5-10a Serial modifications are made to the internal surfaces of the molding appliance with a bur along with the addition of hard acrylic and soft reline material to direct the movement of the alveolar segments in a controlled fashion to produce the desired arch form and reduce the size of the alveolar cleft width.

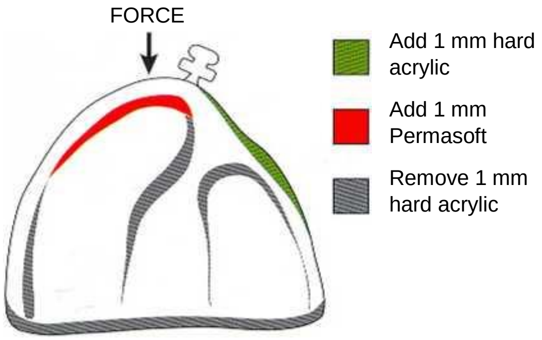


Fig 5-**10b** Diagram showing weekly modifications to internal (tissue) surface of unilateral molding appliance to achieve reduction of cleft width.

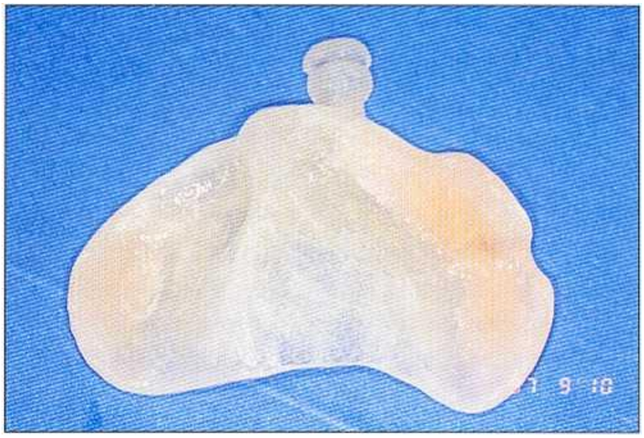


Fig 5-11 Internal surface of unilateral intraoral molding appliance with acrylic retentive button. Permasoft reline material has been added.

used to hold the appliance against the palate. Small red orthodontic elastics (0.1875- or 0.25- inch diameter) (TP Orthodontics, Boulder, CO) are incorporated into the loops of thinner Suture- Strips that are folded over on themselves (Fig 5- 13). The elastic band is placed over the retentive button, and the Suture-Strips are pulled and secured to the base tapes on the baby's cheeks. Enough retentive force has been exerted when the elastics have been pulled to twice their original length. The correct force vector on the retentive tapes and elastics should be directed posteri orlv and superiorly. The Suture-Strips and elastic bands are changed as needed to allow continuous retention of the appliance. The base tapes should remain in place for a longer period of time, while the thin tapes may require replacement several times each day. The base tapes prevent excessive skin irritation on the cheeks that might result from the constant removal of the adhesive tape. Once the Suture-Strips and elastic bands have been applied, an additional broader tape is applied over the ends of the thin tape to anchor them to the base tapes. Additional adhesive (Mastisol, F'erndale Laboratories, Ferndale, MI) may be applied to the base tapes and underlying skin if retention is inadequate. This adhesive may be easily removed by the application of an adhesive releasing agent (Medisol, Orangesol, Gilbert, AZ) to the skin or tape using a cotton swab. If a more rigid taping medium is required, Steri- Strips (3M, St Paul, MN) may be substituted for the more elastic Suture-Strips. If excessive skin irritation develops as a result of the base tapes,

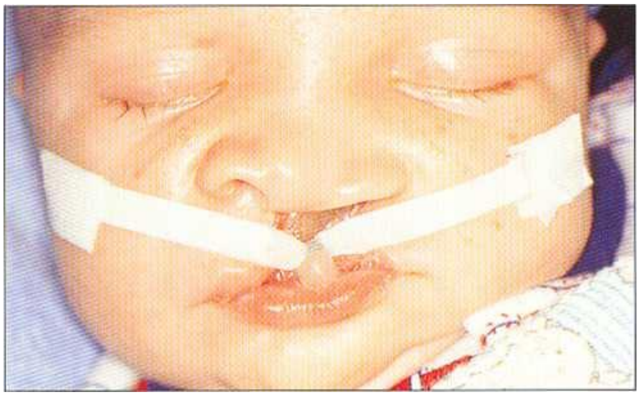


Fig 5-12a Unilateral molding plate secured in the infant's oral cavity with surgical tapes and elastics.

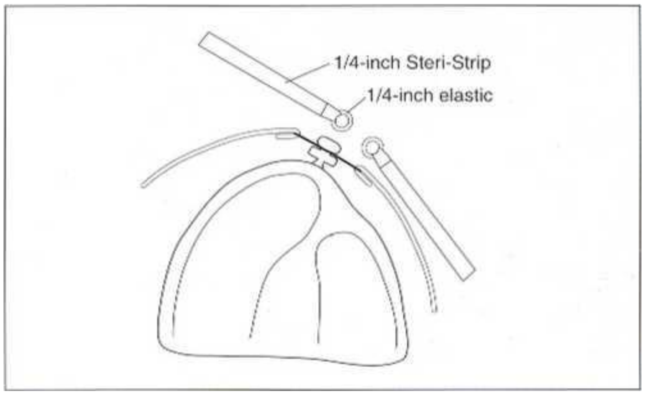


Fig 5-12b Arrangement of narrow retentive tapes and elastic loops.

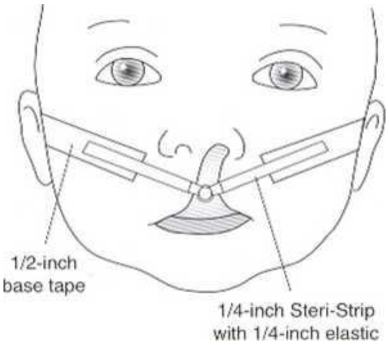


Fig 5-12c Wider tapes on the cheeks provide a foundation for retentive narrow Steri-Strips with elastic loops.

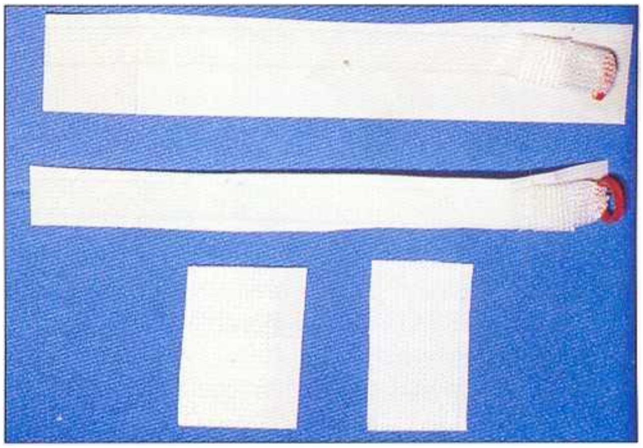
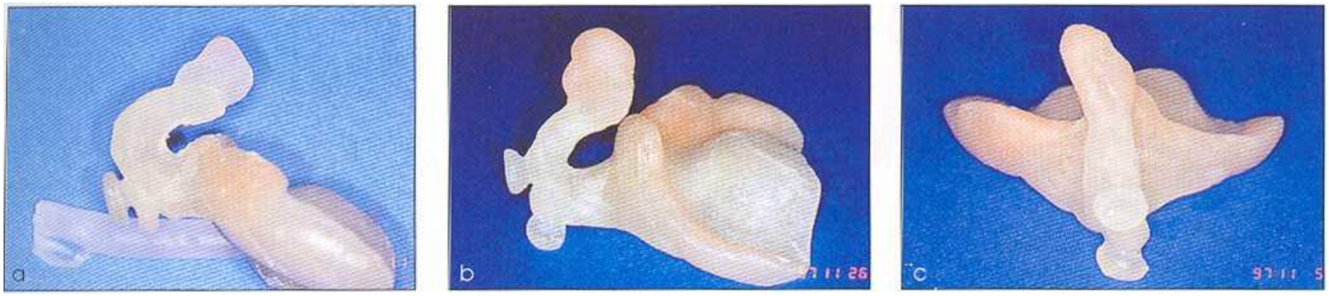


Fig 5-13 Retentive tapes and elastic loops.

Coloplast skin barrier (Coloplast, Marietta, GA) may be substituted. Finally, an additional Suture- Strip is used to gently draw the lip segments together across the lip deft once the molding plate has been inserted and taped into place.

When proper taping of the cleft lip segments is performed, the tape wall serve to help retain the appliance. At the same time it functions much like a lip adhesion that allows the soft tissues of the lip and nasal base regions to become more properly oriented as the nasal stent is developed. While a lip adhesion alone produces uncontrolled orthopedic effects, a lip taping force in conjunction with a molding plate yields a controlled movement of the alveolar segments. The taping of the cleft lip segments also serves to improve the alignment of the nasal base region by bringing the columella toward the midsagittal plane and improving the symmetry of the nostril apertures. The parents are provided with detailed instructions on the proper method of lip taping to ensure the maximum effectiveness of the appliance. A supply of taping materials, adhesive, and releasing agent is also provided to the parents. This ensures continuous taping will be maintained between appointments.

In the case of the unilateral cleft, the infant is usually seen on a weekly basis for follow-up. At each appointment, the progress of the molding appliance is monitored. First, the infant is examined to assess the effectiveness of the taping by the parents. The retention of the appliance is also evaluated. The Suture-Strip tape is removed and the oral cavity is examined for any possible sores



Figs 5-14a to 5-14c (a) Initial nasal stent added in acrylic and (b) modified weekly to its (c) final form.

or ulcerations in areas other than where molding force was applied with the Permasoft. The change in the size of the cleft between the alveolar segments can be measured indirectly by molding extremely soft, white rope wax into the defect and then measuring the thickness of the wax where the cleft was registered. Before beginning any adjustments, the appliance is cleaned with soap and water. The palatal (tissue) surface of the appliance is again modified through selective grinding of acrylic and lining with additional Permasoft material to further reduce the size of the cleft.

The Nasal Stent

When the cleft gap has been reduced to approximately 6 mm or less, a nasal stent may be added to the appliance and the phase of active nasal cartilage molding may begin. The nasal stent is a projection of acrylic that is formed by the careful addition of small amounts of cold-cure acrylic resin until the stent is positioned inside the nasal dome on the cleft side of the nose (Fig 5-14). The nasal stent may also be fashioned from 0.036-inch stainless steel wire secured to the labial flange of the appliance (Fig 5-15). When wire is used for the stent, the wire is carefully bent at the nasal end of the stent to project passively into the nostril. A notch is also bent into wire just below where the stent enters the nostril to provide room for the nostril rim. The entire nasal extension of the wire stent is then covered in hard clear acrylic to provide form and support to the tissues. Finally, the hard acrylic is covered with a thin veneer of Permasoft. We have clinically evaluated several soft liner materials and found Permasoft maintains its resilient qualities without deforming or hardening over the course of molding therapy.

The base of the stent (cither wire or acrylic) should be located above the retentive button described previously. The superior aspect of the acrylic nasal stent is covered with a thin veneer of Permasoft material to ensure that positive elastic pressure is applied to the internal tissues of the nasal dome. The orientation of the nasal stent should be such that the nasal tip and dome on the cleft side are projecting outward (not upward) and toward the cleft side (Fig 5-16a). This will serve as a custom tissue expander that slowly corrects the flattening of the cleft lip nasal deformity. It will also serve to bring the columella into a more mid line position when the lip has been taped with the nasal stent in place. As nasal stenting progresses each week, the nasal tip and dome on the cleft side should begin to appear more symmetric when compared with the noncleft side vvhen the stent is in place. Care must be taken to have enough bulk of Permasoft under the nasal tip to maintain proper tissue form. When properly placed and taped, blanching of the tissue overlying the rip of the nasal stent can be observed as the infant suckles and activates the appliance. The nasal stent also exerts a reciprocal intraoral molding force against the alveolar segments. As the nasal tissues push against the nasal stent, this force is transmitted down along the nasal stent and provides additional force that aids in reducing the dimension of the intraoral

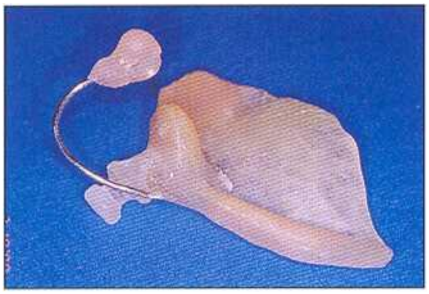


Fig 5-15 Nasal stent fashioned from 0.036-inch wire, acrylic, and covered with Permasoft.

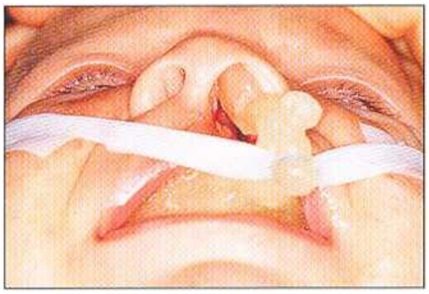


Fig 5-16a Nasal stent positioned in nostril aperture to support dome and reposition lower nasal cartilage (treatment week 13).

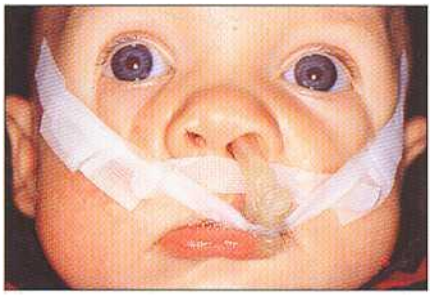


Fig 5-16b Lip taping across cleft. Retentive button now positioned on base of nasal stent. Note additional superior retentive button to allow change in vector of elastic/taping force.

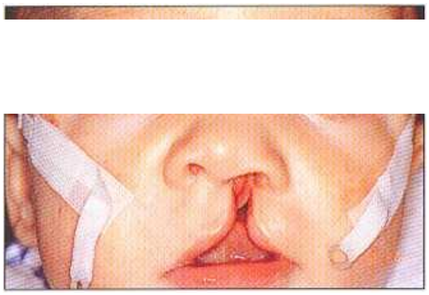


Fig 5-**17a** Cleft nasal deformity after nasal molding just prior to surgery. The alar base is now convex and the nasal tip cartilage has been elevated. The lip segments are now much closer together (see Fig 5-2).

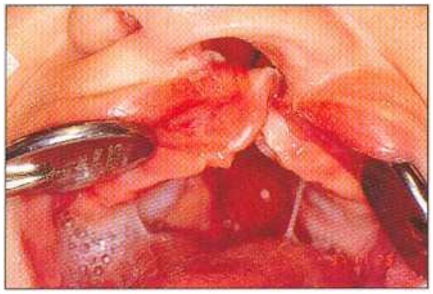


Fig 5-17b Alveolar segments are now in contact as the cleft gap was reduced to zero through intraoral molding (treatment week 14).

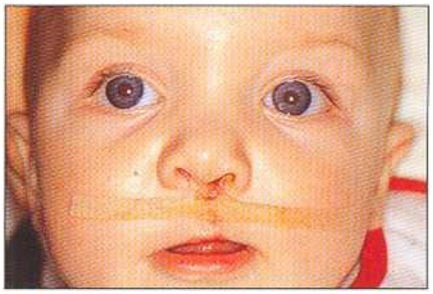


Fig 5-18 Lip taping several weeks after single-stage surgery to repair lip, nose, and alveolus.

cleft width. The parents are again instructed to keep the appliance in place at all times except for cleaning. The acrylic retentive button may need to be removed and repositioned to accommodate the addition of the nasal stent. Often the button is moved to the facial aspect of the nasal stent (Fig 5-16b). A second retentive button may also be added to allow different force vectors to be placed on the appliance. Aggressive lip taping is also continued once the nasal stent has been added to the appliance.

If the appliance has been properly modified and adapted at each visit and utilized continuously with careful lip taping, it is not uncommon to see the alveolar segments in contact after 4 to 6 weeks of oral molding plate therapy in small or moderate-size clefts (less than 10 mm cleft width) (Fig 5-17). The goal of the intraoral molding therapy should be to have the gingival tissues contact on either side of the ridge, although a successful surgical result may be obtained even when a small cleft (1 to 2 mm) remains between the alveolar ridges. The movement of the ridges should be carefully monitored to avoid a situation where there is “locking out” of the lesser segment by the posteriorly directed greater segment. If the greater segment is directed posteriorly more quickly than the lesser segment advances outward, the cleft may close with the lesser segment locked behind the greater segment. The result will be a compromised arch form.

As the intraoral cleft is closing, more aggressive nasal orthopedics may be undertaken as necessary. The nasal stent is continually modified to guide the tissue-expanding force in the desired direction. When the tip of the nasal stent has become covered with an excessive thickness of Permasoft, which is unstable under the pressure from the nasal cartilage, the Permasoft is removed and the tip rebuilt with hard clear acrylic. The new reinforced acrylic tip is coated with fresh Permasoft to continue effective molding. After any adjustment, all methyl methacrylate and Permasoft surfaces in contact with soft tissue must be smooth and without loose tags of material that may create mucosal irritation.

The goal of nasal orthopedics during the later appointments is to ensure that when the lip segments are drawn together with taping the columella has been repositioned to a midline location or even overcorrected prior to surgery. The shape of the nostril and alar rim is also carefully molded to resemble the configuration of the unaffected side. This may be achieved by careful molding with Permasoft on the outside of the nasal rim to support the underside of the expanding soft tissue. This supporting material helps to produce a symmetric teardrop nostril form rather than a simple ovoid or elliptical shape. The nasal molding phase must follow alveolar molding so as to avoid undue stretching of the alar rim circumference on the cleft side. This is more likely to occur if the nasal molding is pursued while a very large cleft alveolar gap remains. It is for this reason that nasal molding should not begin until the intraoral cleft size has been reduced to 6 mm or less. The proper sequence of molding (alveolar followed by nasal) is followed to avoid the production of a “mega-nostril.”

At the conclusion of intraoral molding therapy and nasal stenting, the alveolar segments should be aligned, and the nasal cartilages, columella, and philtrum should be properly repositioned to facilitate the first surgical procedure. This is a one-stage primary lip-nose repair in combination with a gingivoperiosteoplasty (GPP) to close the alveolar defect (Millard and Latham, 1990). This first surgery is usually performed between 12 and 16 weeks of age. This allows one surgical procedure to address the defects of the entire nasolabial complex in coordination with the oronasal presurgical orthopedics. The lip-nose- alveolus repair may be performed at a later age if it is determined by the members of the team that the infant would benefit from additional weeks of nasoalveolar molding prior to surgery. The GPP is of little value unless the alveolar segments have first been molded together to reduce the size of the cleft gap, thereby increasing the likelihood for a successful surgical repair with little growth disturbance in the future.

The infant is seen the week prior to surgery by both the surgeon and dental members of the team for a final evaluation of the lip, alveolus, and nasal position. If the presurgical molding results have been determined to be acceptable, then no modifications are made in the appliance that may introduce tissue irritation just prior to surgery. The appliance is worn continuously by the infant up to the time of surgery. It is removed in the operating room. Following surgical repair of the lip, the lip is taped for several weeks and no intraoral appliance is used (Fig 5-18). Likewise, no nasal stent or supporting device is employed. The palate repair, if indicated, is usually performed at our center in one stage once the infant shows evidence of phoneme speech development. This usually occurs at approximately 11 to 13 months of age.

Clinical Method for Correcting the Bilateral Oronasal Cleft Deformity

In the past, repair of the bilateral cleft deformity relied solely on a surgical approach. The striking feature of the bilateral defect is the short or absent columella, whereas the prolabium has skin that is excessively wide. Previous surgical corrections utilized the skin to reconstruct the absent columella in a multiple-stage approach. This skin paradigm led to excessive scarring at the lip-nose junction and either did not address the nasal tip deformities or made them worse (Fig 5-19). As a result of the successful experience seen here with presurgical nasoalveolar molding in the unilateral cleft condition, the. method was modified to attempt to improve the repair of the bilateral cleft deformity (Grayson et al, 1993). When nasoalveolar molding is applied to the bilateral situation, the skin of the columella and the nasal lining

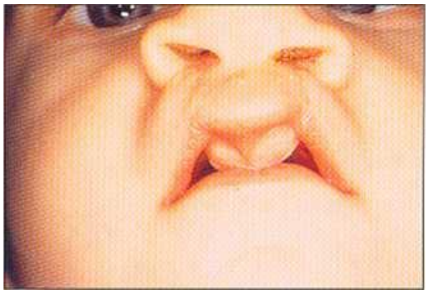


Fig 5-19 Surgical repair of bilateral cleft lip and alveolus defect following skin paradigm approach without benefit of presurgical nasoalveolar molding with columellar elongation. The result was often excessive scarring and the need to surgically create the columella.

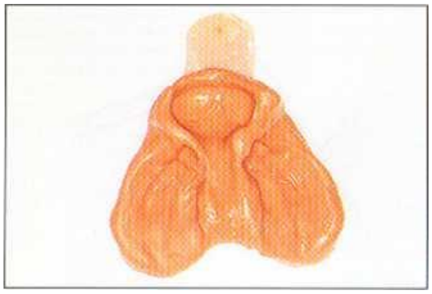


Fig 5-20 Intraoral impression of bilateral cleft deformity with elastomeric material.

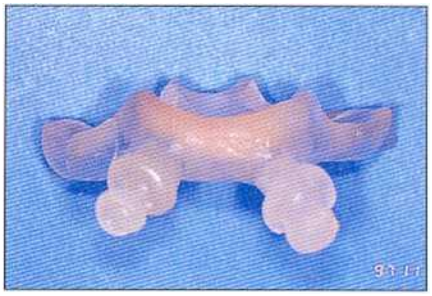


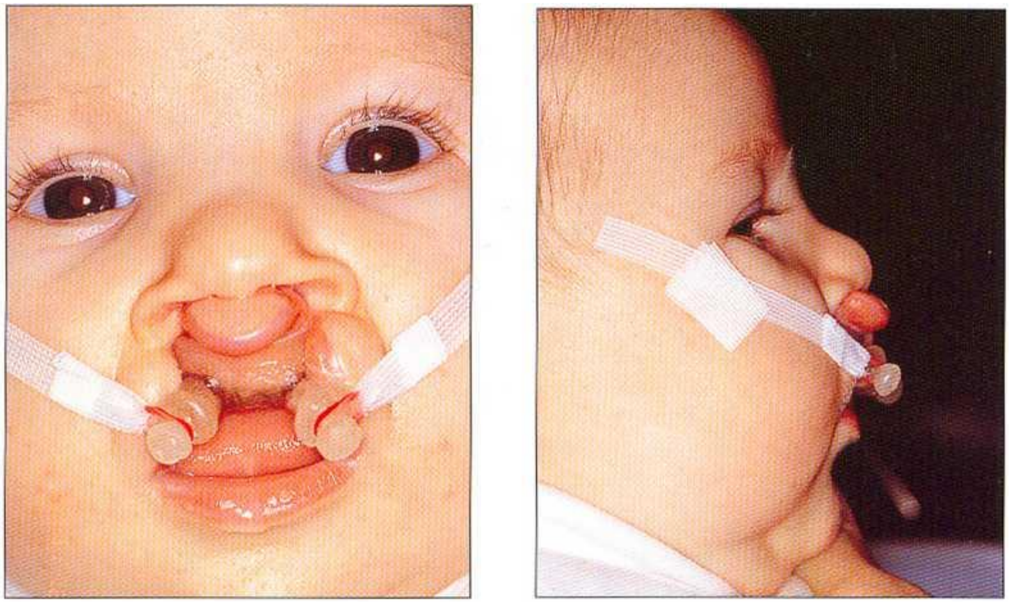
Fig 5-21 Bilateral appliance with double retentive buttons.

tissues are expanded. The nasal cartilages arc also molded presurgically while the premaxilla is retracted into a normal position. The use of presurgical nasoalveolar molding and columellar elongation when combined with a modified surgical repair that focuses on a nasal cartilage paradigm (Cutting et al, 1998) produces a symmetric lip and nose without scars on the nose, columella, or central prolabium after the initial surgical procedure.

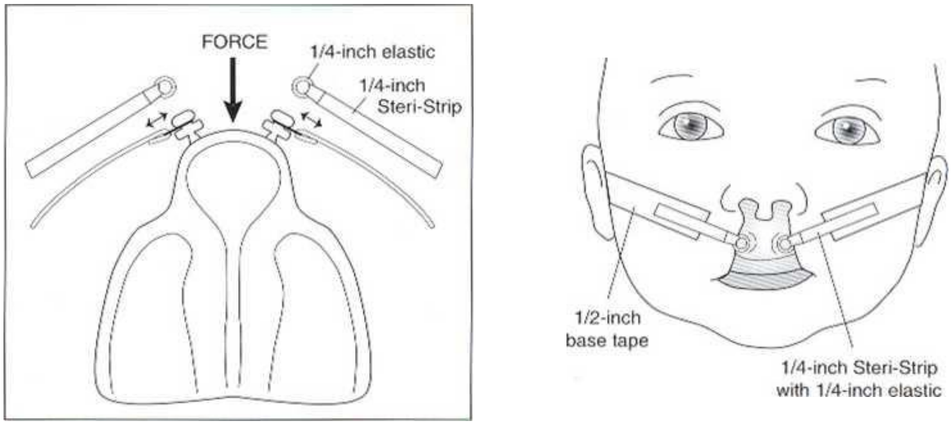
In the bilateral cleft deformity, presurgical nasoalveolar molding consists of three distinct treatment phases. The goal of the first or intraoral phase of presurgical nasoalveolar molding is to align the posterior lateral alveolar segments while retracting and derotating the premaxilla. When the premaxilla has been returned to the keystone position within the maxillary arch, the goal of the second phase is to mold the nasal cartilages by repositioning the apices of the alar cartilages toward the nasal tip. The third and last phase of molding in the bilateral cleft infant focuses on elongation of the columella. Finally, a one-stage surgical repair is undertaken to remove the fibro- fat tissue between the domes of the lateral nasal cartilages as they are sutured together. This is performed along with a bilateral GPP to close the intraoral alveolar clefts.

As in the instance of an infant with a unilateral cleft, the baby with a bilateral cleft is similarly examined by the deft palate team. An elastomeric impression of the bilateral cleft defect is obtained and a clear acrylic intraoral molding plate is fabricated (l'ig 5-20). Two retentive buttons are positioned at a 45-degree angle relative to the occlusal plane to allow for the proper seating and retention of the device (Fig 5-21). Two separate elastics with tapes are used to retain the bilateral molding device (Fig 5-22). In situations where additional force is required to reposition the premaxilla, the elastics may need to be attached to a head cap rather than to tapes adherent to the cheeks (Grayson, 1997). While head-cap traction has been used for many years, the addition of the molding plate results in a more controlled repositioning of the premaxilla. An infant with a bilateral cleft may need to be seen more than once a week during the initial phase of intraoral alveolar molding in order to monitor progress and prevent tissue ulceration that might delay treatment.

The posterior lateral alveolar segments are directed outward to make room for the premaxilla as it is retracted and derotated into a midline position. This is accomplished through the serial adjustments of removing hard acrylic from the areas the segments are being directed toward and adding soft liner material to the regions where force must be applied to the segments to accomplish the movement (Fig 5-23). Again, the preferred soft liner material is Permasoft. The portion of the acrylic plate that contains the premaxilla is modified by adding hard acrylic and soft liner anterior to the premaxilla while hard



Figs 5-22a and 5-22b Bilateral molding plate secured in the infant's oral cavity with surgical tapes and elastics.



Figs 5-22c and 5-22d Arrangement of narrow tapes and elastic loops to retain the bilateral appliance.

acrylic is removed from the region behind it. As the premaxilla is retracted, it is not unusual to see the nasal septum begin to bend to one side. This is unavoidable as the premaxilla moves posteriorly and interiorly. Attention must be given to adjust the palatal portion of the molding plate that contacts the septum as well as any vertical extensions to the plate that rest lateral to the nasal septum. If the premaxilla fails to retract, acrylic preventing the posterior movement of the premaxilla or restricting the lateral bending of the septum is often the cause.

After the premaxilla attains a reasonable position (in most situations after 3 to 4 weeks of retraction), the nasal molding phase of treatment may commence. In the case of the bilateral cleft appliance, two nasal stents are built up from acrylic in the same fashion as for the unilateral nasal stent. Similarly, the paired stents may be fashioned from a single piece of 0.036-inch wire (Fig 5-24). The nasal stents are based on the labial flange of the oral molding plate and have a "swan-neck" configuration as they rise up and enter the nasal apertures. The swan-neck shape allows the prolabium to be safely positioned

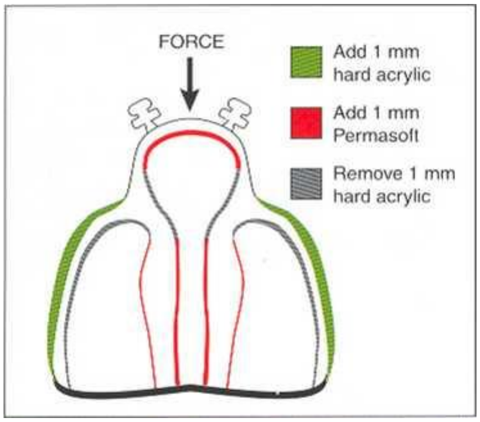


Fig 5-23 Diagram showing weekly modifications to internal (tissue) surface of the bilateral molding appliance to reposition and derotate the premaxilla while reducing the size of the alveolar clefts.

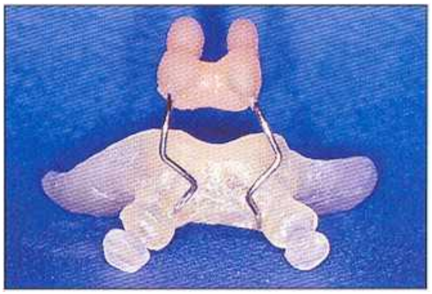


Fig 5-24a Bilateral nasal stent fabricated from 0.036-inch wire and wax former.

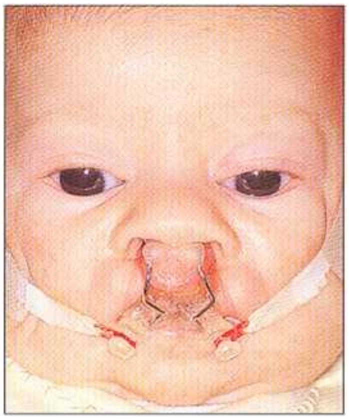
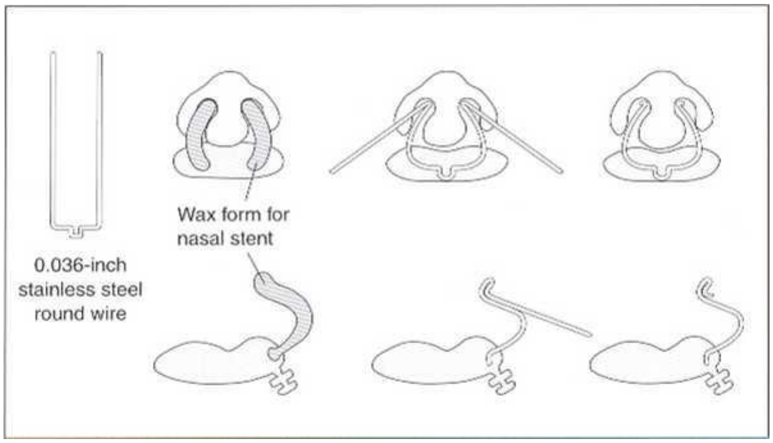


Fig 5-24b Bilateral appliance with nasal stents in position.



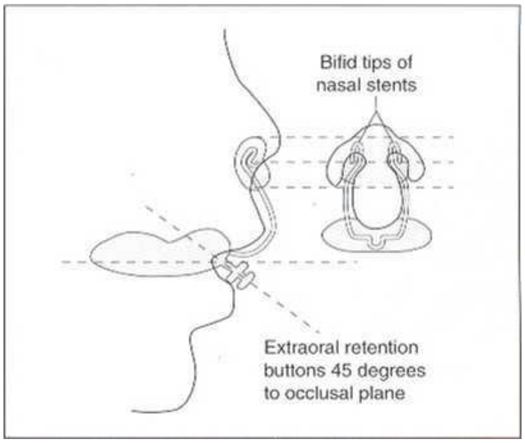

Bifid tips of nasal stents
Extraoral retention buttons 45 degrees to occlusal plane

Fig 5-24c Sequence of bending wire to form nasal stent into "swan-neck" **Fig 5-25** Diagram of nasal stents and bifid stent form. tips properly positioned in nose to elevate carti

lages.

between the two paired stents yet still provides for access to tape the lip during the later phase of columella elongation. The superior aspect of the nasal stents are fashioned to elevate the nasal cartilages on both sides and to provide resistance to the downward pull by a broad tape originating on the prolabium and inserting on the labial aspect of the premaxillary portion of the molding plate. The superior portion of the nasal stents should exert anterior force under the nasal tip on both sides (Fig 5-25). As the stents push anteriorly on the nasal tip there is a reciprocal force directed posteriorly on the premaxilla that facilitates the final millimeters of retraction on that structure. The addition of the bilateral nasal stents to the bilateral oral molding plate allows for predictable and successful retraction of the premaxilla without the need for a pin-retained appliance.

The proper configuration of the nasal stent may be difficult to achieve whether it is fashioned using the acrylic- method or the wire method. White rope wax may be used as a template or guide to shape the stent as it is formed (Fig 5- 24c). The wax is positioned on the labial aspect of the premaxillary portion of the molding plate

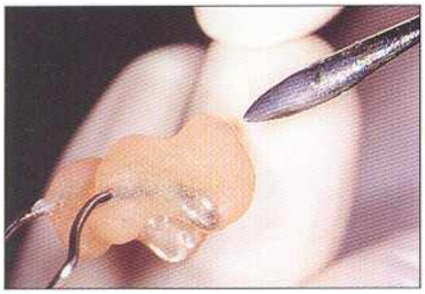


Fig 5-26 Permasoft liner is added to nasal stents to cover hard acrylic. The bifid tips of the nasal stent are modified each week to direct the shape of nasal form.

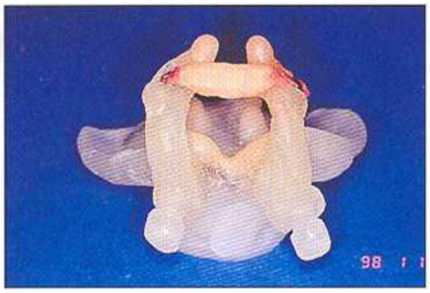


Fig 5-27a Prolabial band made from elastic chain and Permasoft attached to appliance with acrylic nasal stents.

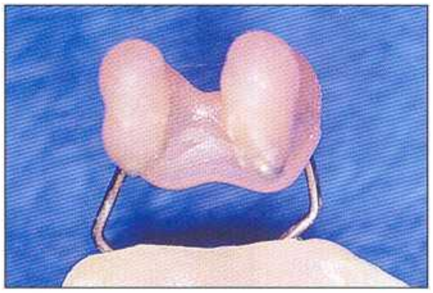


Fig 5-27b Superior view of prolabial band in relation to nasal stents.

and easily molded into the correct shape entering the nose on the baby without concern for setting acrylic or wire projecting into soft tissues as it is being bent. The wax template can then be removed to size the acrylic stent as it is formed by the addition of small increments of acrylic powder and monomer with a brush or as the 0.036- inch wire is being bent using three-prong, heavy bird-beak pliers.

Attention must be given to the shape of the portion of the nasal stents that rest in the nasal tips. The tissue expansion force must be directed straight anteriorly (Fig 5-26). The tips of the nasal stents should be kept close together; otherwise the lip of the nose and possibly the columella will be broadened, which is exactly opposite the desired result. Similarly, the tendency to turn up the nasal tip as the columella begins to be elongated should be avoided. The goal is to bring the domes of the lower lateral cartilages closer together at the midline while expanding the in-lranasal lining tissues.

As the position of the nasal cartilages normalizes, the last phase of molding is introduced. The bilateral nasoalveolar molding appliance with the paired nasal stents is modified once again. A horizontal prolabial band or "saddle" is attached across the two acrylic nasal stents or incorporated into the nasal stents of the wire device (Figs 5- 27a and 5-27b). In the acrylic nasal stent model, the prolabial band is formed from a section of elastic orthodontic chain covered with Permasoft liner in the middle to prevent tissue ulceration. The chain straddles the two nasal stents at the level of the lip-columella junction and is anchored to the acrylic stents on retentive metal buttons incorporated into the facial surface of the stents. The band pushes back against the base of the columella and directs the expansion forces to preserve the nasolabial angle. The downward pull of the surgical tape based on the prolabium that inserts on the labial surface of the molding plate, combined with the posteriorly directed force applied at the nasolabial fold from the horizontal band and the upward and anterior force applied by the nasal stents to the tip of the nose, results in a stretching and lengthening of the columella. Without the prolabial band, the force vector on the columella is directed superiorly rather than anteriorly and the result is a turned-up nasal tip (Fig 5-28).

The tips of the nasal stents are bifid (Fig 5 -27c). The superior lobe enters the nostril pressing anteriorly and slightly upward on the nasal lining behind the dome of the alar cartilage. The inferior lobe of the stent is located under the apex of the nostril sill. As the bifid stent is modified at each appointment with the addition of Permasoft, the nostril apex is projected forward while the inferior lobe serves to preserve the natural form of the nostril. The paired nasal stents should be kept close together to reduce the space between the superior crus of the nasal tip cartilages and to create a columella of appropriate width.

In the wire stent model, the bifid tips of the stents are developed in the wire and again cov-

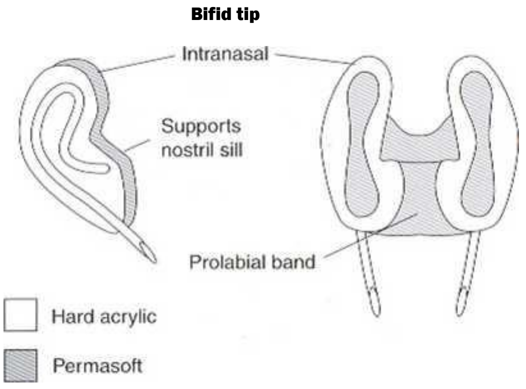


Fig 5-27c Fabrication of the prolabial band for 0.036-inch wire nasal stents.

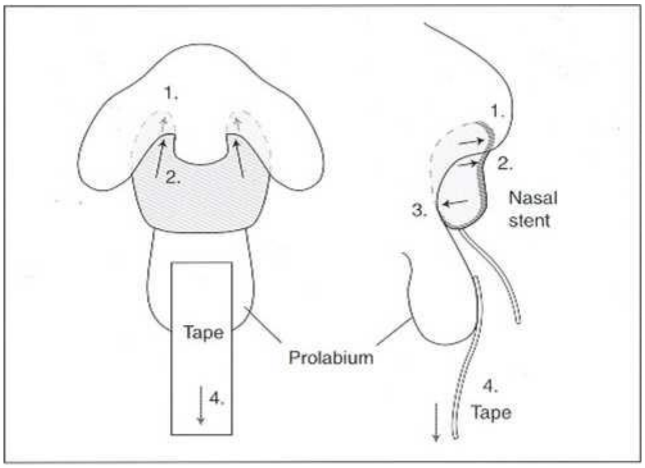


Fig 5-28 Force vectors active in columellar elongation in the bilateral cleft appliance. (?) Anterior and superiorly (applied intranasally), (2) anterior at the nostril apex, *(3)* posterior at the base of the columella (nasolabial angle), and (4) inferior on the prolabium.

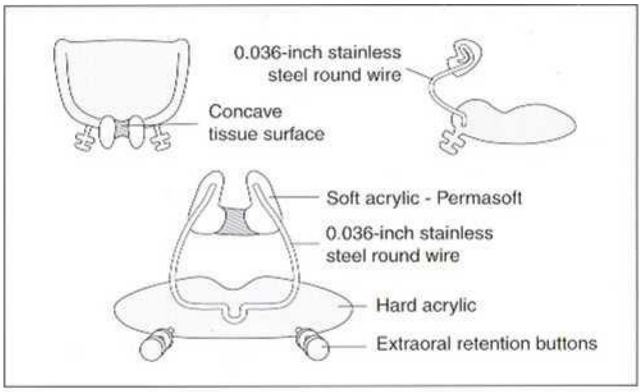
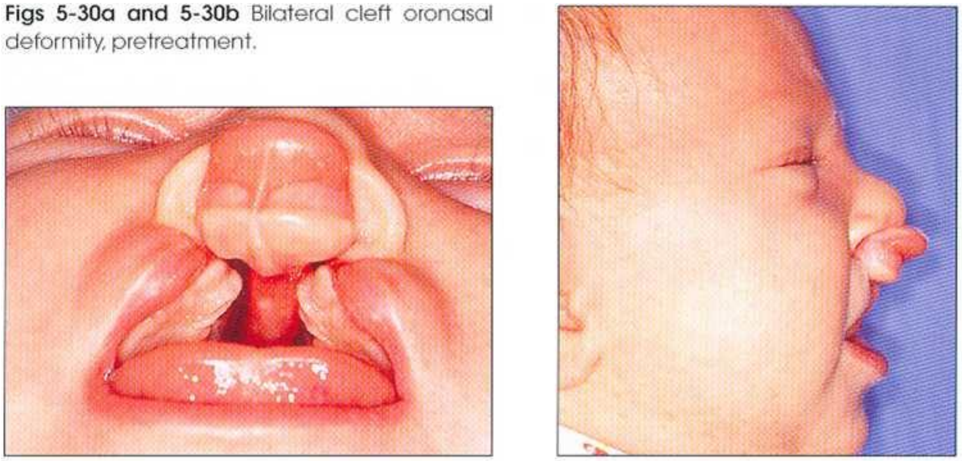

0.036-inch stainless steel round wire
Concave tissue surface
Soft acrylic - Permasoft
0.036-inch stainless steel round wire
Hard acrylic
Extraoral retention buttons

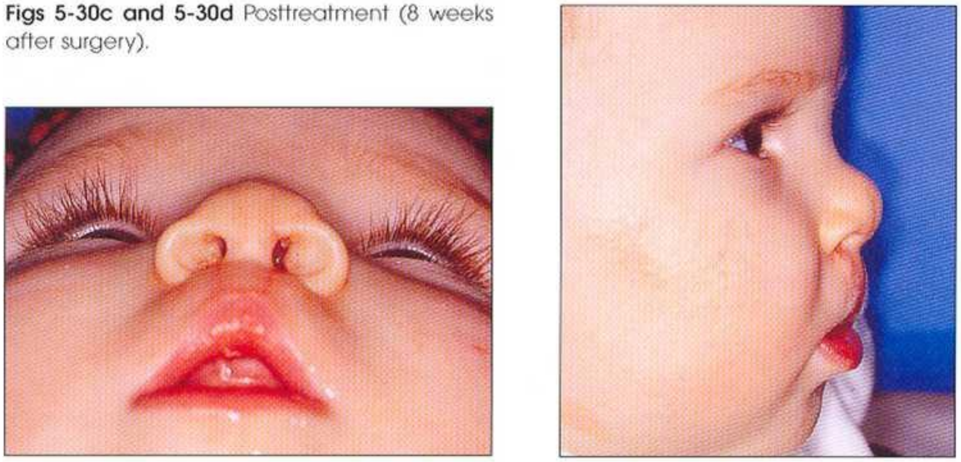
Fig 5-29 Completed bilateral appliance.

ered with acrylic and lined with Permasoft. The prolabial horizontal band is fashioned by extending the acrylic across the two nasal stents, again at the level of the lip-columella junction (at the nasolabial angle) and then covered with Permasoft (Fig 5-27c). Care must be taken to prevent excessive pressure at the lip-columella junction by the prolabial band, or tissue breakdown and ulceration will develop. If ulceration develops at the lip-columella junction, then the taping of the prolabium to the labial surface of the molding plate will need to be stopped until healing takes place. This will delay the elongation of the columella. In general, the entire process of nasoalveolar molding and columella elongation must be considered a form of custom tissue expansion, and focus must be on developing a balance between exerting enough force to maintain tissue expansion while preventing tissue breakdown. Therefore, while each prosthesis will have the same components, it must be remembered that each appliance is a custom tissue expander that must be constructed to meet the treatment needs of each individual child (Fig 5-29).

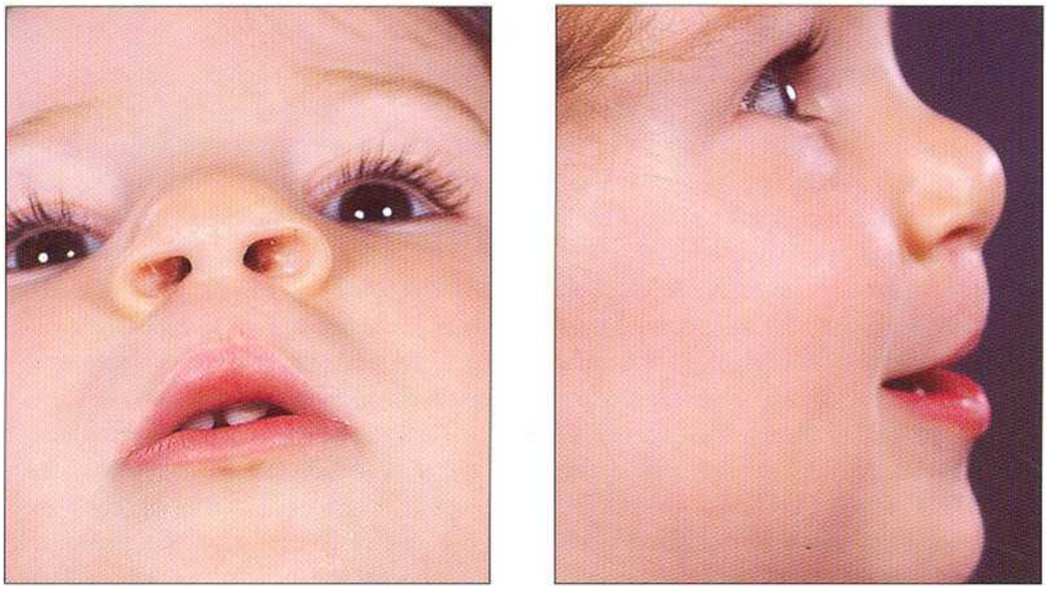
One of the most significant benefits of the bilateral application of nasoalveolar molding is the nonsurgical lengthening of the absent columella (Fig 5-30). Using this technique, the columella may be nonsurgically lengthened between 4.0 and 7.0 mm (Grayson et al, 1999). The success of nasoalveolar molding and columella elongation in the bilateral cleft infant, however, is dependent



Figs 5-30a and 5-30b Bilateral cleft oronasal deformity, pretreatment.



Figs 5-30c and 5-30d Posttreatment (8 weeks after surgery).



Figs 5-30e and 5-30f One-year postoperative result.

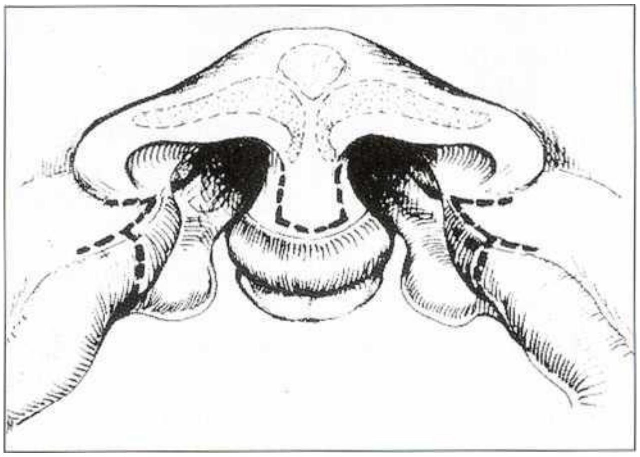


Fig 5-31 a Bilateral nasal deformity, pretreatment. Fibrofat tissue is located between alar cartilages. (Figs 5-31 a and 5-31 b reprinted with permission from Cutting CB, Grayson BH, Brecht LE, et al. Presurgical columellar elongation and primary retrograde nasal reconstruction in one-stage bilateral cleft lip and nose repair. Plast Reconstr Surg 1998; 101 (3):633.)

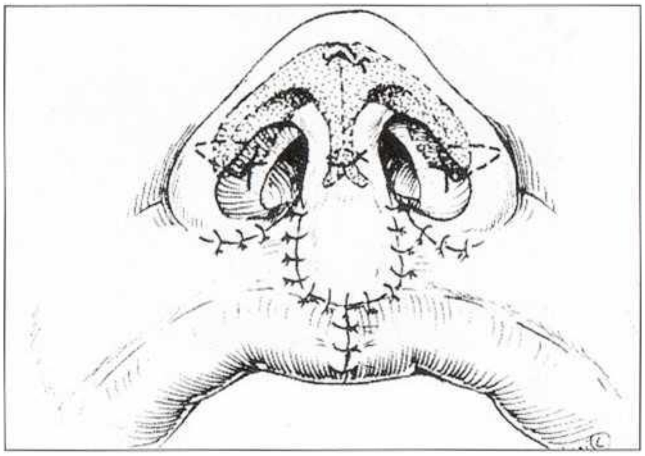


Fig 5-31 b Nasal cartilages sutured together following repositioning through nasoalveolar molding. Fibrofat between cartilages has been removed during one stage lip, alveolus, and nasal repair.

upon its coordination with a modified nasal correction surgery (Cutting et al, 1998). Presurgical molding alone cannot remove the skin and fibrofat tissue located between the widely separated nasal dome cartilages. If this adipose tissue is not removed and the tips of the nasal cartilages are not sutured together, the benefits of molding the malpositioned nasal cartilages will eventually be lost and there will be an increased likelihood for lateral drift of the alar bases (Fig 5-31). Even with a modified surgical repair to address the fibrofat tissue, intentional overcorrection of the columella is encouraged to minimize postsurgical relapse.

In the infant with a bilateral cleft, it is not unusual that nasoalveolar molding and columellar elongation will require up to 5 or 6 months of active treatment before the surgical repair. As in the case of the unilateral molding appliance, the device is worn continuously and removed only for cleaning. The infant wears the prosthesis into the operating room. No intraoral appliance or nasal stent is employed postsurgically. The lip, however, is taped for several weeks while the baby heals.

Surgical Techniques of Nasoalveolar Molding and Columellar Elongation

While presurgical nasoalveolar molding has greatly improved the foundation for the surgeon to repair the unilateral cleft defect, and PNAM in conjunction with columellar elongation has revolutionized the approach to the bilateral cleft repair, it cannot be overemphasized that the success of these new techniques is also dependent upon the modification of the surgical procedure employed to repair the cleft. A coordinated effort is imperative.

Both the unilateral and bilateral surgical repairs utilize a modified GPP as described by Millard and Latham (1990). While the technique is more difficult when the cleft segments are in close opposition,, their proximity increases the likelihood that bone will form across the repaired cleft. The experience at our center has been that almost 65% of infants who have undergone a coordinated approach of presurgical molding

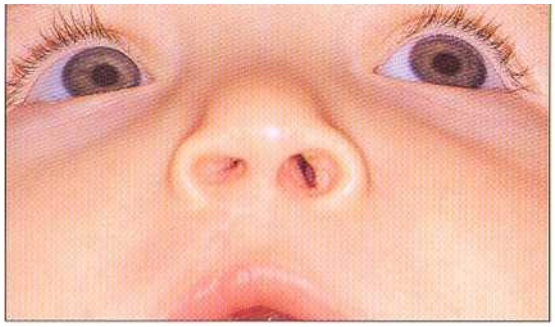


Fig 5-32 Mega-nostril (patient's left nostril).

combined with a modified GPP did not require a subsequent alveolar bone graft at the age of eruption of the adult canine (Santiago et al, 1998).

While nasoalveolar molding increases the length of the columella in the unilateral cleft nose (as well as in the bilateral condition) and normalizes the position of the lateral alar cartilages, it does not fully correct the cleft nasal deformity. The unilateral surgical repair employed at our center is a modification of the technique first described by Blair and Brown (1930) and later by McComb (1985) and Salyer (1986). Through the addition of presurgical nasoalveolar molding, the current surgical repair (Cutting, 1994) no longer requires an extensive dissection of the lower lateral cartilages, and scar contracture is reduced. The bilateral surgical technique is described in detail by Cutting et al (1998). Its key feature is the suturing together of the domes of the nasal tip cartilages that have been repositioned through presurgical nasal stenting.

Complications Associated with Presurgical Nasoalveolar Molding and Columellar Elongation

The Locked-out Segment

Perhaps the most common hard tissue complication associated with presurgical nasoalveolar mold ing is misdirected molding of the alveolar segments or locking out, as previously described. This may result from poor management of the molding process. Should a segment become locked out or positioned behind another, it may be remedied through corrective molding if recognized early in therapy. If it is not remedied, the position of the maxilla in the locked-out region will tail to provide the desired soft tissue support, although a successful alveolar closure may be achieved. The resulting misshapen maxillary arch form will eventually have to be corrected ortho- dontically.

Nostril Overexpansion

The most serious of the soft tissue complications is overexpansion of the alar rim in the unilateral cleft nose resulting in a nostril that is too large relative to the unaffected side. This is termed a *mega-nostril* (Fig 5-32). The most common cause for the development of a mega-nostril is addition of the nasal stent before the size of the cleft gap is adequately reduced. Premature stenting places excessive force against the nasal tissues leading to excessive expansion. The direction of the tissueexpanding force as well as its progress must be closely monitored on a weekly basis. There should be adequate bulk of material on the tip of the nasal stent extending into the dome so that the radius of the tip will be large enough to exert a gentle expansion force without causing tissue breakdown. The force vector on the nasal tip must be directed anteriorly, not superiorly. Although there mav be some tissue shrinkage

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after surgery, the development of a mega-nostril may require the surgical removal of a wedge of tissue at the base of the nostril at the time of the initial surgical repair.

Tissue Ulceration

Occasionally an area of ulceration may develop intraoral ly or in the nasal region where active molding pressure is applied. These ulcerations usually resolve without intervention. They may result from an ill-fitting appliance or from the addition of too much material in an attempt to rapidly mold the alveolar segments. The appliance may also be coated with a small amount of tissue lubricant in the area of irritation. Ulcerations in regions where active molding is not underway should be investigated and the appliance modified as needed. Ulceration of the nasal soft tissues also may result from too-rapid tip projection and cartilage molding. No ulcerations should be allowed to develop just prior to surgery. Surgical repair may need to be delayed to allow for the tissues to heal if an ulceration develops in the region where an incision will be made.

Skin irritation as a result of taping is most effectively managed by slightly changing the position of the base tapes whenever they are changed. Skin care products with aloe vera may be applied to the irritated areas.

Failure to Retain Appliance During Oronasal Molding

If the appliance is not adequately retained during the course of treatment, either by the failure of the parents to properly apply tapes and elastics during molding or through poor compliance with scheduled follow-up appointments, earlier progress of molding therapy will likely be lost. If the appliance is lost or not worn, a cleft that had closed earlier during molding therapy may widen again as the infant places the tongue into the cleft in the attempt to suckle. It is therefore imperative that the parents become active members of the treatment team. Support, education, and encouragement of the parents by the members of the cleft palate team during treatment is crucial. Less than ideal results of oronasal molding therapy are often seen in infants with less than ideal parental involvement and compliance. A commitment to regular weekly appointments is paramount.

Failure to Tape Lip Segments

Ineffective appliance taping or lip taping may lead to a nonretentive appliance and very slow progress in the closure of the cleft. Additionally, improper or less aggressive taping will not maximize the potential for soft tissue expansion during the period of plasticity. Taping should firmly coapt the lip segments as well as support the appliance. There may be a tendency for the soft tissue to exert an opposing downward force that will dislodge a poorly taped appliance, especially once the nasal stent is actively positioned within the nostril.

Exposure of a Primary Tooth

Occasionally an ectopic primary tooth bud may be enclosed in a soft tissue sac in the region of the cleft. Its presence may be registered in the impression. The anatomic crown of a primary tooth may also be exposed as a result of the pressure applied during active intraoral molding. The decision should be made by members of the cleft palate team on an individual basis as to whether the tooth should be retained or removed depending upon its location, its prognosis, and the surgical plan. No alteration in development of primary teeth exposed during molding has been observed.

Complications and compromised presurgical nasoalveolar molding and columellar elongation may be avoided by constant awareness that each molding device is a unique appliance for each individual infant and the characteristics of the particular cleft. Although the general goals and principles of treatment will be applied to each patient, the resulting appliances are all quite different in their appearance and the relative importance of each of their components.

Benefits of Presurgical Nasoalveolar Molding and Columellar Elongation

In both the unilateral and bilateral cleft situations, the use of PNAM provides numerous advantages over surgery alone to repair the cleft without presurgical molding. Presurgical nasoalveolar molding allows for the controlled, predictable repositioning of the alveolar segments without the need for lip adhesion surgery or for the surgical insertion of a pin-retained dynamic molding plate. The reduction in the size of the cleft gap facilitates the repair of the entire lip-nose-alveolus complex in one surgical procedure. It also allows the surgeon to perform a GPP without the need for the extensive tissue dissection required when the alveolar segments are far apart. As a result, studies have shown no midfacial growth restriction in children who have undergone a GPP following presurgical molding with reduction in the size of the deft gap (Wood et al, 1997) when compared with children who had GPPs without presurgical cleft gap reduction. PNAM used in conjunction with GPP also reduces the need for additional surgery to bone graft the alveolus later in childhood and reduces the need for early nasal revision surgery as the child enters school (Lee et al, 1999). The reduction in the need for several additional surgical procedures is extremely cost-effective (Pfeifer and Cutting, 1998). The child does not undergo additional hospitalizations, general anesthesia, or postoperative time away from school.

The nasal component of molding facilitates the final phases of intraoral molding as the nasal stent provides a reciprocal force that is transmitted downward along the stent and against the alveolar segments as they are closing. This is very helpful since as the infant grows older the bone of the alveolar segments becomes more calcified, dense, and resistant to molding. The additional force from the nasal stent often provides the final push that allows the alveolar segments to meet. Similarly, the intraoral molding plate provides a foundation that enhances the function of the nasal stent as it acts on the nose.

In the bilateral cleft patient, PNAM combined with columellar elongation eliminates the need for columellar lengthening surgery. As a result of the elimination of this surgery to create a columella, there is no scar at the lip-nose-columella junction and the esthetics of the entire nasolabial complex is optimized.

Both the unilateral and bilateral prostheses improve the infant’s ability to feed. In their most basic form, the devices serve as obturators that provide an intact palatal surface upon which the infant will now be able to generate a suckling force. The infant is able to feed in a shorter period and with less effort once the intraoral molding plate has been delivered.

Limitations of Presurgical Nasoalveolar Molding and Columellar Elongation

Despite the numerous advantages of these new techniques, there are several drawbacks associated with PNAM and columellar elongation. For optimal effectiveness, the molding process should begin as soon as possible after the baby is born. As the newborn becomes older, the plasticity of both the hard and soft tissues is reduced and molding becomes more difficult. In addition, the older child is more likely to learn to dislodge the molding appliance and the retentive tapes and elastics, especially once the nasal stent has been added. While this does not prevent the employment of PNAM and columellar elongation, it does make the process more difficult and the parents must monitor the child more closely.

PNAM and columellar elongation therefore require cooperative parents who must be well informed of the importance of their integral role in the successful outcome of the treatment. They must be able to have the child seen regularly by the treatment team, usually on a weekly basis. This, however, often proves to be a very positive experience for the parents. They are able to interact with the team members in a face-to-face setting every week and have their questions answered and tears allayed. Also, the parents may interact with other parents whose children may be farther along in the treatment sequence. The parents are able to see the progress of the older children each week. Parents caring for infants undergoing PNAM and columellar elongation universally report they feel actively involved in the care of their children and as a result have a greater understanding of the cleft condition and future treatment that their child may need.

These techniques are very labor intensive and require a committed dental team and a surgeon committed to “handing over” care of the infant to the dental team for the first 4 to 6 months of care. The surgeon must be committed to learning the modifications of the surgical techniques needed to optimize the results provided by presurgical intervention. The dental team members (at our center, an orthodontist and a prosthodontist) may expect to spend between 30 and 90 minutes at each appointment with a child, depending upon the treatment required at a particular session. As an infant undergoing PNAM and columellar elongation will need to be seen regularly, this technique may not be practical in situations where the parents must travel great distances to receive weekly care.

Conclusion

While the use of presurgical infant orthopedic devices remains controversial, a growing collection of studies has shown that presurgical nasoalveolar molding and columellar elongation provide safe, effective, and lasting improvements in the esthetics of the nasolabial complex in infants with unilateral or bilateral cleft deformities (Brecht et al, 1995; Wood et al, 1997; Cutting et al, 1998; Santiago et al, 1998; lee et al, 1999; Lin et al, 1999; Maull et al, 1999). These studies support the role of nasoalveolar molding as a form of custom tissue expansion while correcting the nasal cartilage deformity nonsurgically and resolving the columellar length deficiency and alveolar segment malposition with minimal surgery.

Since its development at the Institute of Reconstructive Plastic Surgery at New York University Medical Center, this emerging technique is currently being successfully utilized in a growing number of cleft palate centers throughout the United States, Asia, South America, and Europe. Those teams of parents and professionals who do make the commitment to provide presurgical nasoalveolar molding and columellar elongation will have served their infants and patients with a state-of-the-art method to improve the cleft condition through the least surgically invasive technique currently available.

References

Blair V, Brown J. Mirault operations tor single harelip. Surg Gynecol Obstet 1930;51:81.

Brecht L, Grayson B, Cutting C. Columellar elongation in the bilateral cleft lip and nose patient. I Dent Res 1995;74:257.

Cutting C. Cleft lip nasal reconstruction. In: Rees TD, LaTrenta GS (eds). Aesthetic Plastic Surgery, Vol I. Second edition, Philadelphia: Saunders, 1994:497.

Cutting C, Grayson B, Brecht L, Santiago P, Wood R, Kwon S. Presurgical columellar elongation and primary retrograde nasal reconstruction in one-stage bilateral cleft lip and nose repair. Plast Reconstr Surg 1998;101:630.

Grayson B, Cutting C, Wood R. Preoperative columella lengthening in bilateral cleft lip and palate. Plast Reconstr Surg 1993;92:1422.

Grayson P>, Santiago P. Presurgical orthopedics for cleft lip and palate. In: Aston S, Beasley R, Thorne C (eds). Grabb and Smith’s Plastic Surgery, ed 5. Philadelphia: I ,i ppincott- Raven, 1997:237.

Grayson B, Santiago P, Brecht L, Cutting C. Presurgical nasoalveolar molding in infants with cleft lip and palate. Clell Palate Craniofac J 1999;36:486.

Latham R. Orthodontic advancement of the cleft maxillary segment: A preliminary report. Cleft Palate) 1980; 17:227.

Lee C, Grayson B, Brecht L, Cutting C, Lin W. The need for surgical columella lengthening and nasal width revision before the age of bone grafting in patients with bilateral cleft lip following presurgical nasal molding and columella lengthening. Presented at the 56th Annual Meeting, American Cleft Palate-Craniofacial Association, Scottsdale, AZ, April 1999. Cleft Palate Craniofac J (in press).

Lin W, Grayson B, Brecht L, Lee C, Cutting C. Effect of presurgical nasal molding on unilateral cleft lip and palate. Presented at the 56th Annual Meeting, American Cleft Palate-Craniofacial Association, Scottsdale, AZ, April 1999. Cleft Palate Craniofac J (in press).

Maull D, Grayson B, Cutting C, Brecht L, Bookstein F, Kltorrambadi D, ct al. Long-term effects of nasoalveolar molding on three-dimensional nasal shape in unilateral clefts. Cleft Palate Craniofac J 1999;36:391.

McCornb H. Primary correction of the unilateral cleft lip nasal deformity: A 10 year review. Plast llcconstr Surg 1985;75:791. '

McNeil C. Orthodontic procedures in the treatment of congenital cleft palate. Dent Rec 1950;70:126.

Millard D, Latham R. Improved primary surgical and dental treatment of clefts. Plast Reconstr Surg 1990;86:856.

Mylin W. The pin-retained prosthesis in cleft palate orthodontics. Cleft Palate J 1968;5:219.

Pleifer T, Cutting C. Gingivoperiosteoplasty versus alveolar bone graft: An outcome analysis of costs in the treatment of unilateral cleft alveolus. Presented at the 55th Annual Meeting, American Cleft Palate-Craniofacial Association, Baltimore, MD, April 1998. Cleft Palate Craniofac J (in press).

Salyer K. Primary correction of the unilateral cleft lip nose: A 15 year experience. Plast Reconstr Surg 1986; 77:558.

Santiago P, Grayson B, Gianoutsos M, Kwon S, Brecht L, Cutting C. Reduced need for alveolar bone grafting by prc-surgical orthopedics and primary gingivoperiosteoplasty. Cleft Palate Craniofac J 1998;35:77.

Wood R, Grayson B, Cutting C. Gingivoperiosteoplasty and midfaciai growth. Cleft Palate Craniofac J 1997;34:I7.

Clinical Management of the Edentulous Maxillectomy Patient

o Rhonda F. Jacob, DDS, MS

Tumors of the hard palate, maxillary sinus, and sometimes the buccal mucosa or nasal cavity require surgery called a maxillectomy or maxillary resection. The hard palate is the anatomic floor of the maxillary sinus. Depending on the extent of the tumor, maxillary resections can be performed that do not violate the integrity of the hard palate. Maintaining the hard palate, however, is the exception rather than the rule. Violation of the hard palate creates an anatomic defect that allows the oral cavity, maxillary sinus, nasal cavity, and nasopharynx to become one confluent chamber. Lack of anatomic boundaries creates disabilities in speech and deglutition. Air, liquids, and food bolus escape from the oral cavity to exit the nares, making adequate oral nutrition difficult if not impossible. Speech becomes unintelligible due to hypernasality[f] distorting sounds that require impounding of air within the oral cavity. Prosthetic intervention, with a maxillary obturator prosthesis, is necessary to restore the contours of the resected palate and to recreate the functional separation of the oral cavity and sinus and nasal cavities. Prosthetic intervention should occur at the time of surgical resection and will be necessary for the remainder of the patient’s life. This chapter discusses the primary surgical enhancements that can improve prosthesis outcome and patient acceptance, the time sequence and phases of prosthetic procedures, prosthetic techniques and materials, and troubleshooting patients’ functional complaints.

Surgical Enhancements

Surgical enhancements have been suggested to prepare the defect for optimal prosthetic rehabilitation. Some procedures offer definite advantages; others have minimal influence on prosthetic function and primarily add a burden of time and perhaps morbidity to the surgical procedure. The following are primary enhancements that aid the edentulous maxillectomy patient.

1. *Maintain as much hard palate as possible.* Since the edentulous patient must rely on the remnant of the hard palate for primary retention, support, and stability, the surgeon should be encouraged to resect only enough hard palate to allow adequate tumor margins. The more ipsilateral premaxillary area that can be maintained, the more of a tripoding prosthetic effect that can be achieved (Fig 6-1). This adds stability to the prosthesis, and the increased surface area will enhance retention. In addition, when one maintains the anterior alveolus and the floor of the nose, there will be less collapse of facial form and less postoperative contracture. Attachments of muscles of facial expression will also be preserved (Fig 6-2).

2. *Skin graft the cheek flap.* In the classic maxillectomy, the check is elevated away from the maxillary bones, and the pterygoid muscles and the bones are resected. This leaves a denuded surface on the entire cheek flap, remnants of the pterygoid muscle bed, and soft palate musculature

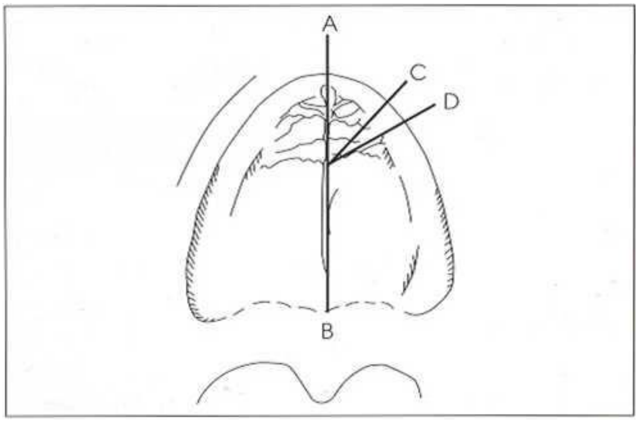


Fig 6-1 Although a cut from A to B is technically easier to perform, surgeons should be informed of the tripoding effect created by maintaining the premaxillary area, which adds stability and increased surface area for prosthesis retention. Even the slight increase of surface area created by the DB cut offers increased stability when compared with the CB cut.

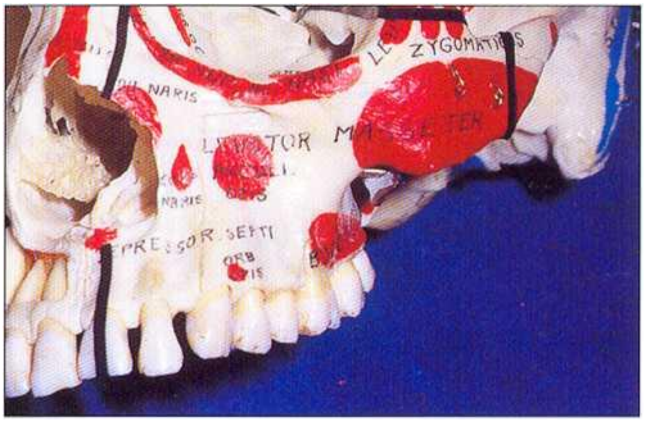


Fig 6-2 Note the facial muscle attachments that are sacrificed with a maxillectomy. Depending on extent of the tumor, the superior cut of the maxillectomy may only include the alveolar process (infrastructure maxillectomy) or the floor of the orbit (total maxillectomy).

originating from the pharyngeal wall. If this area is allowed to heal by secondary intention, the healing time will extend many weeks with a bleeding surface. Eventually the surface will be covered with respiratory epithelium migrating from the nasal cavity' and nasopharynx. This mucosa does not serve well as prosthesis-bearing tissue and is easily abraded. Respiratory epithelium will also add to the mucous secretions that the patient must clean from the cavity. A split-thickness skin graft can be placed over these denuded surfaces at the time of tumor surgery. This graft will be prosthesis bearing in 10 to 14 days and after a few weeks of maturation can be aggressively cleaned and approximated by the prosthesis. This skin-lined surface will not secrete mucus. Due to differential contracture of the skin graft and the mucosa of the oral cavity, a scar band will form along the lateral check at the junction of the skin graft with the remaining buccal mucosa, and in the pterygoid muscle area. It has often been stated that this scar band will aid retention because it is an anatomic undercut. This area can be quite mobile when the patient moves the mandible, however, and the changes in contour must be accommodated in the obturator impression. The constant motion of this minimal undercut in the lateral check usually makes this area of little use for retention. Despite the movement of the deep anatomic undercut in the pterygoid and soft palate musculature (superior to the cut edge of the soft palate), this undercut area often serves to retain the posterior aspect of the prosthesis from complete dislodgment.

Many maxillofacial texts suggest that the placement of a skin graft will decrease the contracture of the cheek flap. It is accepted that a split-thickness skin graft will contract over 50% of its volume, so it is questionable that healing by secondary intention would create any more contracture of the cheek flap. The primary determinants of contracture of the face are amount of residual bony support and ancillary therapies, such as radiotherapy. For practical purposes, one should view the skin graft as a sound prosthetic-bearing surface that will not be easily abraded, does not secrete mucus, allows for vigorous cleaning of the defect, and may aid in retention.

3. *Remove the inferior turbinate.* If the hard palate is resected to expose the nasal cavity, the inferior turbinate is also exposed. If the tumor does not involve the nasal cavity, the inferior turbinate will likely not be resected. Anatomically this structure is only millimeters above the cut edge of the hard palate and covered with respiratory epithelium. Maintaining the inferior turbinate will preclude extending the medial wall of the obturator bulb into the nasal cavity. Height of

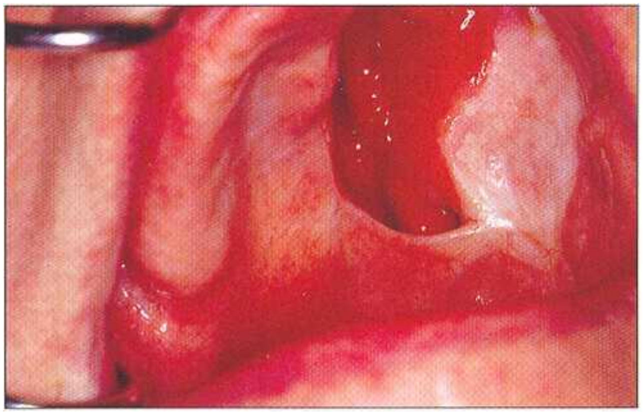


Fig 6-3 The more anterior and inferior the resection, the more the facial bony wall of the maxillary sinus remains intact. In this patient it was surfaced with a split-thickness skin graft. The bone can then be used for vertical support of the prosthesis.

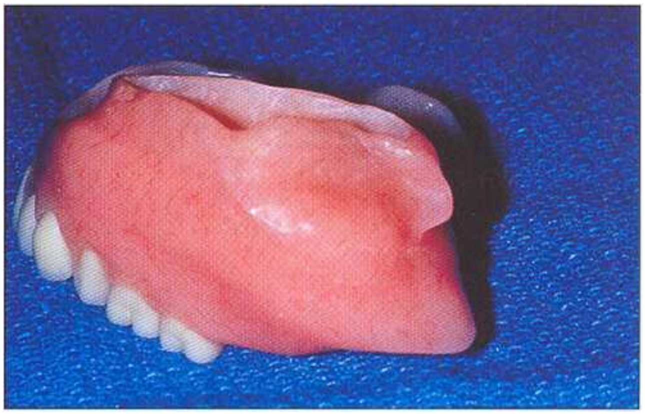


Fig 6-4 The posterior bony wall of the sinus (from Fig 6-3) is reflected in the superior aspect of the obturator bulb.

this medial wall counters rotation of the prosthesis during function. It also allows liquids that reflux into the cavity at the medial periphery of the bulb to be redirected back into the oropharynx instead of running forward and out the nares. Functional movement is inevitable with an edentulous obturator prosthesis, and movement against the turbinate is likely to cause bleeding. To have space within the surgical defect for height of the medial wall of the obturator bulb, the inferior turbinate should be resected at the time of tumor surgery.

4. *Skin graft the maxillary sinus walls.* When tumor involves the hard palate with minimal involvement of the maxillary sinus walls, the hard palate will be resected and most of the bony walls of the sinus will remain intact. These walls can be prepared during surgery to allow the bony undercuts to serve for retention or for vertical support to keep the prosthesis from rotating into the defect during mastication. The sinus walls are covered with respiratory mucosa, which must be denuded and covered with a split-thickness skin graft (Figs 6-3 and 6-4). Grafting the sinus walls stops formation of polypoid tissue and mucus generation within the sinus and allows the walls to become load-bearing areas.

Phases of Prosthetic Restoration

Surgical Obturator Prosthesis

Use of an immediate surgical obturator is less common for the edentulous patient than the dentate patient because of the seemingly invasive method of securing the prosthesis. Securing the prosthesis requires use of a palatal bone screw, sutures into the surrounding mucosa, or circum- zygomatic wires. Regardless of the method of securing the prosthesis, the procedures needed to fabricate the surgical obturator are identical. An alginate impression of the maxilla is made with conventional denture coverage. If any tumor bulk is present on the alveolus or hard palate, this area of the cast should be reduced to normal contour. To ensure that the prosthesis will not be overextended at the peripheries of the surgical defect, the prosthesis should have border extensions identical to a complete denture. One *should* avoid estimating the extent of the surgical peripheries, especially in the soft palate and pterygoid area. The surgical packing will close any discrepancies in the surgical defect margin and the prosthesis margin. It will not be necessary to fabricate multiple prosthescs nor perform any intraoperative reductions of border extensions. The prosthesis can be fabricated with heat-processed resin or autopolymerizing resin. The composite resins are convenient but quite brittle. They can fracture with placement of the wires or screws used to secure them intraoperatively. A heat- processed baseplate is not necessary because the prosthesis will be used for less than 10 days.

Bone screw retention

The palatal bone screw can be placed through a midpalate hole predrilled through the acrylic resin baseplate in the midpalate at the anterior peak of the palatal vault. This position will allow placement of the screw into the vomer. The hole should be drilled from the palate to the intaglio surface and angled posteriorly. The body of the screw should be allowed to move freely in all directions within the hole, with a countersink border around the periphery of the hole to accept the head of the screw. Allowing the screw body to move freely will preclude any binding of the screw against the prosthesis as it engages the vomer. A 13- to 16-mm self-tapping screw should be used to ensure enough length to pass through the denture and achieve adequate bone retention. These bone screws arc usually titanium or stainless steel and are available in mandibular fracture armamentarium (Fig 6-5). Using the denture as a surgical guide, it is often necessary to drill a small starting hole through tissue and the palatal bone to allow screw placement. One midpalatal screw is adequate, but if the vomer is resected, two screws placed at conflicting angles through the denture in the lateral hard palate (at the junction of the alveolus and the palatal vault) will secure the prosthesis. The contralateral maxillary sinus may be entered with the screws, but this wound heals readily after removal of the surgical prosthesis. A small plug of tissue conditioner or poI vvinvlsiloxane over the head of the screw will keep the screw attached to the denture in the event the patient dislodges the denture during the postoperative period.

Suture retention

In a previously irradiated patient, one might elect to use the suture technique to avoid placing a bone screw in the irradiated palate. Sutures placed at the periphery of the prosthesis may be secured into the soft tissues at the height of the vestibule, against the bone of the remaining maxillary alveolus. The surgical side will be secured along the internal surface of the cheek. Individual 2-0 silk sutures can be passed through six to eight predrilled holes in the lateral and anterior borders of the acrylic resin baseplate (Fig 6-6). Each suture is secured with a knot against the denture flange in the middle of the suture and each one tagged with a hemostat. The baseplate is then taken to the oral cavity- and each suture passed through the soft tissue and tied. It is not necessary to suture across the soft palate for adequate retention and soft palate sutures are difficult to remove when the patient is in the clinic. There will be slight prosthesis movement with this technique, but the packing will be secured and the prosthesis will not dislodge.

Circumzygomatic wire retention

Wires are passed over the zygomatic arch and threaded through two bilateral holes placed in the premolar area of the baseplate flange. This technique is the most invasive and has greatest morbidity-' when removing the wires in the clinical setting. It is not commonly used. The palatal bone screw offers the most stability of the three options. The bone screw, sutures, and packing can be removed without sedation, but the clinician should be forewarned that syncopal episodes may occur during packing removal with or without sedation. Sedation is often not necessary if petrolatum gauze packing is used in the defect, as there is little discomfort when removing it. Sedation can also reduce the patient’s ability to understand management instructions concerning the prosthesis.

Use of the existing maxillary denture

Some texts suggest using the patient’s existing denture for the surgical obturator and for the subsequent interim obturator prosthesis, but there are disadvantages to using the existing denture at the surgical or interim phase. Once an attempt has been made to use the existing denture (baseplate plus dentition), the patient will expect it to be used throughout the entire prosthetic

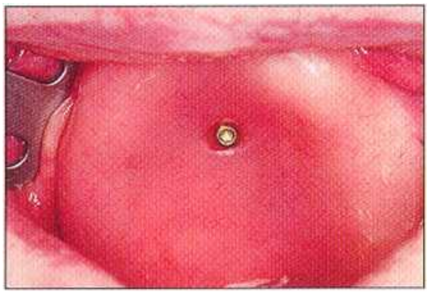


Fig 6-5 A 13- to 16-mm palatal bone screw, angled posteriorly to allow oral access for a full-length screwdriver, retains the surgical obturator prosthesis.

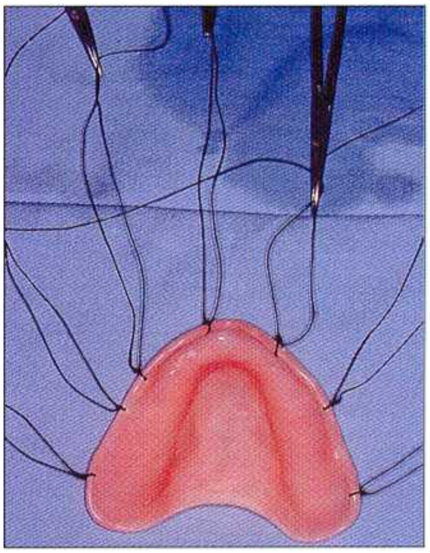


Fig 6-6 *(right)* Multiple 2-0 silk sutures can be used to retain a surgical obturator prosthesis and surgical packing.

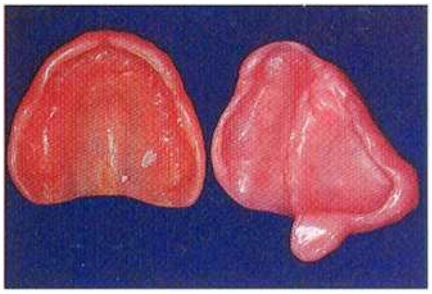


Fig 6-7 The contour of the original denture is contrasted with the peripheral contracture evident just 4 weeks postsurgery. A speech aid was added over the soft palate to obturate the pharynx because of poor velopharyngeal closure. This extension was not necessary after the patient's soft palate completely elevated into position over the next few weeks.

period. When the surgical defect involves approximately one half of the hard palate, maintaining a comfortable occlusion while constantly reducing and relining the flanges of an unstable obturator prosthesis is almost impossible. If the maxillary denture is ill-fitting preoperatively, it will be necessary to reline the denture prior to surgery. If the fit is not optimized prior to surgery, it may not be possible to establish appropriate position of the denture when securing the denture intra- operatively. Despite the denture reline, achieving appropriate occlusion when securing the obturator with a bone screw, wires, or sutures is very unlikely. Patients will need to discontinue use of the mandibular denture during the surgical obturator phase due to these occlusal discrepancies.

The same difficulties are observed postoperatively. If the maxillary denture is not relined prior to the surgery, it will be necessary to reline the surgical defect and the residual hard palate surface while attempting to maintain occlusion with the mandibular denture. Even with presurgical relining of the denture base, attempting to maintain comfortable occlusion with the continual refines required on the surgical side is nearly impossible. Of greater concern are the postoperative changes that will occur in the maxillary surgical borders over the next several weeks. As facial contracture occurs, the anterolateral border of the denture will require significant reduction (Fig 6- 7). It is not uncommon that the contracture is so great that the anterior teeth are soon extended beyond the obturator prosthesis periphery. The teeth on the surgical side often require facial reduction and ultimately removal from the baseplate due to overextension. If the teeth are not reduced, the lip is too protruded and unseats the prosthesis. At this time the surgical contracture is usually not complete; therefore, it is too soon to move into the definitive obturator prosthesis. The clinician must decide to replace the anterior teeth or perhaps remove the remaining teeth on the nonsurgical side. If the teeth are repositioned, they will likely be in a negative horizontal overlap with the lower teeth. A number of appointments over several weeks is required to continue to adapt the interim obturator prosthesis. When the patient’s dentures are used, the appointment procedures are more complex and the appointments might increase in number, compared to using a baseplate-only prosthesis. The need for these additional visits, additional discomfort, and possibly the need to make a new maxillary or mandibular prosthesis (or at least major repositioning of teeth) during the interim phase should be explained to the patient. The majority of patients and their families are accepting of a baseplate without dentition to negate the aforementioned personal and financial costs. When patients insist upon maintaining dentition, however, they must be aware of the additional fees.

Interim Obturator Prosthesis

In addition to restoration of speech and swallowing, the edentulous maxillectomy obturator demonstrates the complication of poor prosthesis retention and instability in both the interim and definitive prostheses phases. Every step of prosthesis fabrication should maximize prosthesis adaptation to hard and soft tissues. This will enhance retention and stability to ensure optimal speech and swallowing, jaw relationship records, tooth placement, final esthetics, and final occlusion. Most of the patient management information and clinical techniques for the various prosthetic steps are applicable in the interim and definitive prostheses phases. Though the materials may be slightly different and the patient's stage of healing is different, the clinical procedures are similar. The interim prosthesis phase is treated in detail below.

Chairside impression of the surgical site 5 to 10 days after surgery

The baseplate used for the surgical obturator can be relined and modified to serve as the interim prosthesis. Optimal border seal and extension is needed in the remaining hard palate. The baseplate can be border molded and relined on the remaining hard palate. After this is accomplished and the base is stable, the periphery of the surgical defect is impressed. The ideal material has varied viscosity by altering the monomer and polymer ratio and can be manually shaped. Truesoft (Harry J. Bosworth, Skokie, IL) can be placed incrementally along the periphery of the defect. By placing a viscous mix of material and wetting the clinician's latex glove, the borders of the obturator prosthesis can be manually and arbitrarily extended to resemble the periphery of the defect. The prosthesis is seated in the mouth with each increment of material, and the impression is made to capture a few centimeters of periphery at a time. Excess material can be cut away with scissors. Any impression material that was severely distorted during seating of the material can also be removed with scissors. With the initial mix of tissue conditioner serving as a tray, a lighter wash of material can be incrementally placed over the surface if reading of the impression surface reveals that the material is short of contact or if the cutback area needs refining. The clinician should continue this procedure around the entire periphery until the defect is sealed.

Using this incremental shaping method creates a hollow, light prosthesis (Fig 6-8). The internal aspect of the impression can be filled with tissue-conditioning material if desired, but this adds considerable weight and is not recommended. In either situation, the entire defect should not be impressed at once. Many times patients have a postoperative decreased oral opening, and attempting to impress the entire defect at once only wipes the material away when placing the tray. It is also difficult to carry material into anatomic undercuts if the entire defect is impressed at one time.

Patient movements, speech, and swallowing evaluation during border molding

'l'he patient should be directed to use routine head and mandible movements when making the impression of the remaining hard palate. The impression of the surgical side requires that the patient perform exaggerated head movements turning right to left with the head level and then again with the neck flexed and extended. The mouth should be opened and closed, and the mandible moved laterally. The patient should also be asked to swallow. The clinician should maintain control of the impression throughout the entire procedure by manually supporting the tray. Some clinicians have a tendency to rotate the tray into the defect site; therefore, the tray should be supported against the remaining hard palate with the fingers directing a vertical force diagonally toward the residual palate-alveolus junction (Fig 6- 9). With each increment of material, the prosthesis should be carefully evaluated to determine that the prosthesis is not dislodged by head or jaw movement. If there is a dislodging force, the

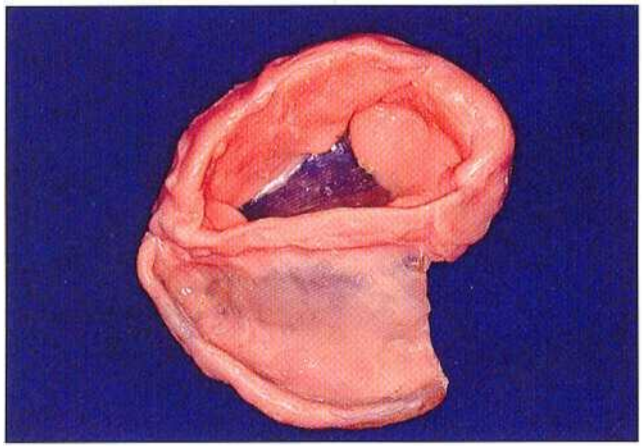


Fig 6-8 The surgical baseplate obturator prosthesis can be relined on the palatal and surgical sides the same day as packing removal. This prosthesis can be immediately flasked and converted to acrylic resin to serve as the interim obturator prosthesis.

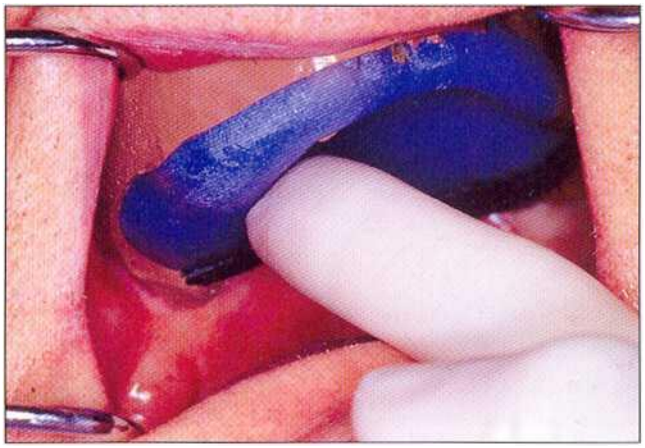


Fig 6-9 During impression making for edentulous maxillec- tomy patients (interim or definitive phase), it is important to support the prosthesis through all functional border movements. The force should be diagonally directed against the residual hard palate and alveolus to prevent rotating the impression into the surgical defect.

new portion of material should be cut back and reimpressed in that area. Swallowing and head movements should always be made with every addition of material. If the clinician does not use functional border molding, the prosthesis will be less stable and the patient will experience tissue irritation in a short time.

The peripheries of the bulb portion will likely be 2 to 3 cm in height. There is no need to add material to fill the entire sinus space; it only adds w'eight to the prosthesis and offers little to the border seal. The superior defect area will also contract between visits and will create a considerable dislodging force on the prosthesis. The inferior aspect of the prosthesis should be at the level of the original hard palate and soft palate junction. Many times the cut edge of the soft palate, or the skin graft, extends inferior to the plane of the hard palate, but when the prosthesis is extended below the palatal plane two problems occur: (7) The space required for tongue function is violated. With speech and with every swallow the prosthesis is dislodged superiorly into the defect by the tongue. *(2)* The injured soft palate junction will contract and elevate back to the level of the hard palate very rapidly over the next 2 weeks, and if the prosthesis periphery has been arbitrarily lowered to make contact with the cut edge of the soft palate, the prosthesis will be overextended and become irritating a few days after the clinical visit (Figs 6-10 and 6-11). To achieve border seal and adequate speech restoration, the posterior border will be extended over the cut edge of the soft palate to extend to the posterior aspect of the defect. Anatomically the prosthesis should contact residual soft palate muscles, pterygoid muscles, or the pharyngeal wall.

Even during the early interim phase, it is possible to achieve normal speech. The clinician must develop an ear for nasality in speech. In the English language, the only speech sounds that are formed when air passes through the nasal cavity are *m, n*, and *ng.* In all other speech sounds, the anatomic barriers of the hard and soft palate and the combined functional motion of the soft palate and pharyngeal walls (velopharyngeal closure) serve to keep the air in the nasal cavity separate from the air in the oral cavity. When air is obstructed from passing from the vocal cords out the nose during the m, », and *ng* sounds, hy- ponasal speech is evident. This occurs frequently

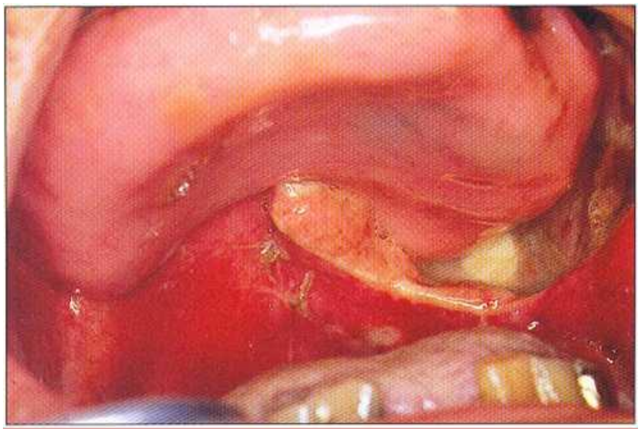


Fig 6-10 this soft palate is hanging below the level of the palatal plane and inferior to the interim obturator at 5 days postsurgery. The surgical site is well obturated and the functional tongue space is maintained by keeping the prosthesis border superior to the soft palate.

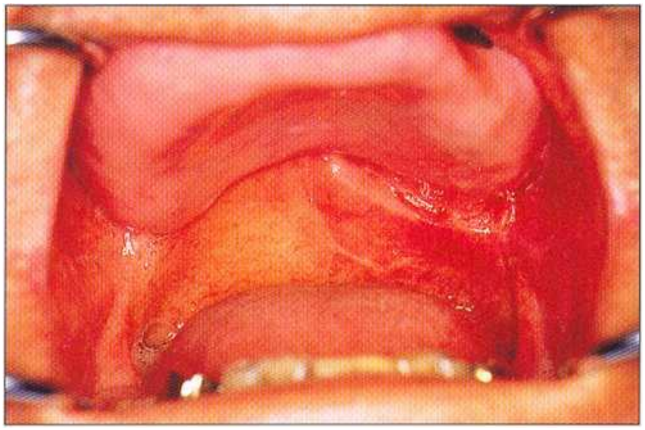


Fig 6-11 The soft palate has elevated considerably 2 weeks later without requiring adjustments to the inferior aspect of the prosthesis.

during the common cold when the nasal passages become obstructed from edema or mucus. Hypernasal speech occurs due to loss of air from the oral cavity into the nasal cavity. In the case of the maxillectomy patient, this loss of air occurs because of an anatomic defect in the hard palate. Without the obturator, the loss of air into the nasal cavity is so great that a patient's speech is unintelligible. As the periphery of the prosthesis is sealed at the surgical site, air loss will diminish and speech becomes normal.

Examining the peripheral surface of the obturator bulb and ensuring peripheral tissue contact will correct hypernasal speech in most instances. Final analysis for appropriate speech is to listen for distinction between the letters *m* and *b*. The patient should say several words beginning with the *b* sound. If the *b* is clear and distinct, then no air escape is occurring. If the *b* sound cannot be distinguished from the *m* sound, then air escape is still occurring. The patient should also say the word *beat*, then manually occlude the nares and again say the word *beat*. If there is a difference in sound quality between the two test words, hypernasality' remains. If the speech is still slightly hypernasal, a slight addition of a light or less viscous mix of material at the soft palate junction should be attempted. The lit may also be tested while drinking water with the head upright. The liquid should pass easily without the patient experiencing reflux into the nose or sinus cavity'.

Patients may not be able to control liquids in the oral cavity at the early interim phase, and drooling due to postoperative swelling and anesthesia of the upper lip on the surgical side from loss of the ipsilateral anterior-superior alveolar nerve is often observed. The patient must be encouraged to place the drinking cup lateral to the midline to assist in sensation of the liquid and told to approximate the lower lip tightly with the upper lip when swallowing. When the packing is initially removed, the cheek may be very flaccid and allow lateral air escape through the oral commissure, but the area will contract within a few days and improved air and bolus control should occur.

Insertion of the interim prosthesis

After the tissue conditioner impression, the entire tray and impression can be used as a wax pattern. It can be flashed, completely removed from the stone mold, and the mold packed in autopolv- merizing or heat-processed resin. The prosthesis may be hollowed further to decrease weight. The goal is to have a well-fitting, lightweight prosthesis. The prosthesis should be delivered within a

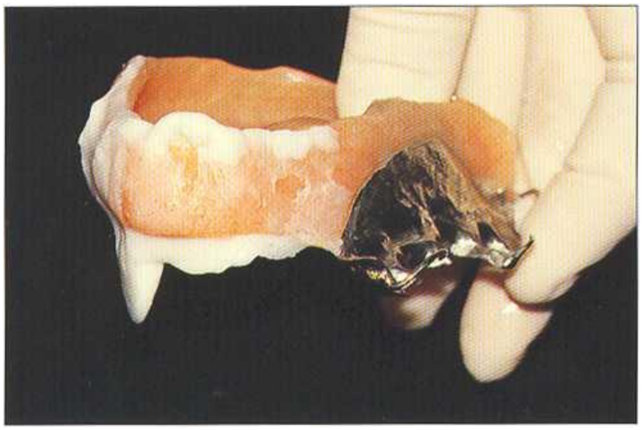


Fig 6-12 Delivery of any obturator should include a functional impression with a tissue-conditioning material. This material allows better assessment of functional movement as compared to pressure-indicating paste.

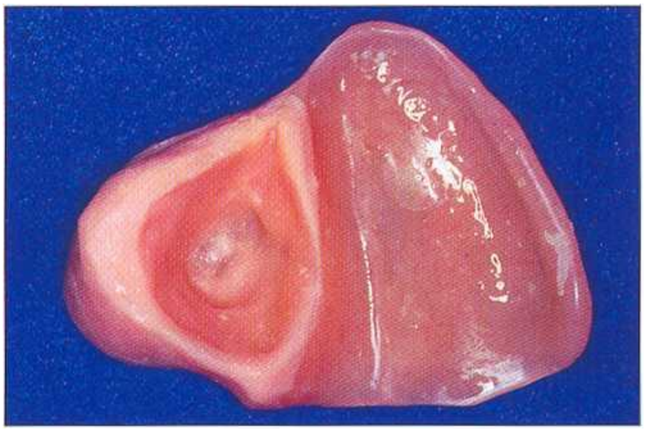


Fig 6-13 This interim prosthesis requires further revisions several weeks after surgery. The periphery of the tissue-conditioning material is reduced several millimeters and a midline finish line is created. A new wash of material is placed over the previous material, which acts as a supporting tray.

few hours of making the impression. Keeping the prosthesis overnight will likely result in a prosthesis that does not fit into the defect. Tissue edema will occur and the defect will change shape rapidly after removal of the packing. This phenomenon occurs for many months or even years after the surgery, particularly if most of the supporting walls of the maxillary sinus were resected or if the patient had ancillary radiotherapy. The patient should be instructed not to leave the prosthesis out for more time than is needed to clean it or the surgical site. When having repairs made to the prosthesis, the patient should have the prosthesis returned the same day or wear a spare prosthesis.

At delivery of the prosthesis, the intaglio surface of the remaining hard palate area and cut edge of the hard-palate area should be checked with pressure-indicating paste. Since pressure-indicating paste will frequently smear when placing the prosthesis into the defect area (giving a false reading), the periphery of the bulb portion is ideally disclosed with a light-body tissue-conditioning material of a contrasting color (Soft-tone, Harry J. Bosworth). To allow easy removal of the material after the procedure, a thin coating of petrolatum is placed on the periphery of the bulb. The tissue conditioner is placed on approximately one third of the surface area at a time. The prosthesis is positioned and the patient directed to go through appropriate movements and swallowing. This is a functional impression, so the tissue conditioner will be thin in the pressure areas (Fig 6-12). After adjustment of these areas, the remainder of the bulb periphery can be incrementally assessed.

Patients must regularly use a powdered adhesive to retain the prosthesis, so changing the tissue conditioner to acrylic resin in the interim prosthesis allows use of the adhesive on the hard palate area. Few edentulous maxillectomy patients function satisfactorily without adhesives. Patients must practice placing and removing the prosthesis before leaving the office. They should be told that a head-upright position during the swallow will decrease leakage of liquids through the nose. Patients should be followed in 24 hours to monitor use and cleaning of the prosthesis and to reinforce instructions.

Revisions

Every 10 to 14 days over the next 2 months, the prosthesis will require revisions due to tissue changes in the surgical site. If radiation is added to the regimen, the tissue changes may occur for several months. Patients should be advised that adjustments arc needed if pain or bleeding occurs or if the prosthesis will not scat. However, they should be reassured that increased hypernasality and nasal reflux is primarily a nuisance; there will be no physical or medical complications if patients experience speech or reflux difficulties between office visits. Between visits, the tissue-conditioning material becomes quite firm, and on subsequent visits the surface can be reduced with laboratory burs or rotary sandpaper and then resurfaced with more material. Upon return visits, the clinician should routinely reduce the cavity borders at least 5 mm (Fig 6-13). The original bulk of the material should be maintained as a tray to support the new material added to the surface. It will likely be necessary to reduce the prosthesis along the lateral and posterior walls of the cavity. It is usually not necessary to readapt the cut surface of the hard palate for several weeks, as this bony wall will not change until the bone remodels. The prosthesis should be evaluated to determine if the prosthesis will seat completely and not move with jaw and head movements. If movement of the mandible creates movement of the prosthesis after border reduction, more material should be reduced in the overextended areas. Some visits may ret]uire removal of considerable bulk of existing material due to tissue contraction. If the original tissueconditioning material or acrylic resin shows through the new addition of material, these areas should be further reduced and reimpressed. Overextension of the prosthesis occurs readily with tissue changes, and the clinician should be aware that major reductions in the extension of the bulb may be required.

When the surgical site becomes more stable, with fewer major adjustments needed (usually in 1 to 2 months), the tissue conditioner can be used as a laboratory reline impression. It is possible to flask the obturator prosthesis, completely cover ing the contralateral palatal surface and any areas of acrylic resin in the drag (base portion) of the flask. The tissue conditioner can remain exposed and be covered in the cope (second stage) of the flask. The tissue conditioner can then be processed with autopolymerizing resin, polished, and returned to the patient. It may be several more weeks before the surgical area is completely stable, without tissue changes. This may be 6 to 12 months following completion of therapy. A longer time may be necessary with larger resections and with adjuvant radiotherapy, which adds to tissue contraction.

Definitive Obturator Prosthesis

Preliminary impression

The preliminary impression should offer maximum extension within the surgical site. When the maxillary surgical cavity is large, regardless of the tissue or bony undercuts within the cavity, it is not necessary to block the cavity with gauze prior to the impression. Blocking of the defect adds time and patient discomfort, and the material often shifts during the impression, thereby creating an underextended impression. It is prudent to block palatal fistulas that open into intact maxillary sinus or nasal cavities. Impression material can mushroom into the intact cavities and tear from the impression during removal of the tray. This is most likely to occur with alginate impression materials. The fistulas can be blocked with a piece of gauze or cotton, tied with floss extending out of the mouth, and wedged tightly into the fistula.

A stock edentulous tray will serve well for the preliminary impression tray. If one uses a fluid alginate, such as Jeltrate (LD Caulk, Dentsply, Milford, DE), it will be necessary to support the surgical side of the material with compound or wax and likely necessary to inject the material into the surgical cavity before seating the loaded tray. This requires additional time to shape the tray and fabricate a custom nozzle for a 60- to 100-mL syringe to inject the alginate material. An alternative is to use a stock edentulous tray with an alginate of greater viscosity (Supergel, Harry J. Bosworth). The surgical side of the tray can be loaded with more material. The viscous alginate will carry into the cavity and capture the borders (Fig 6-14), It will not be necessary to add wax or compound to the tray, nor to inject the material into the surgical cavity.

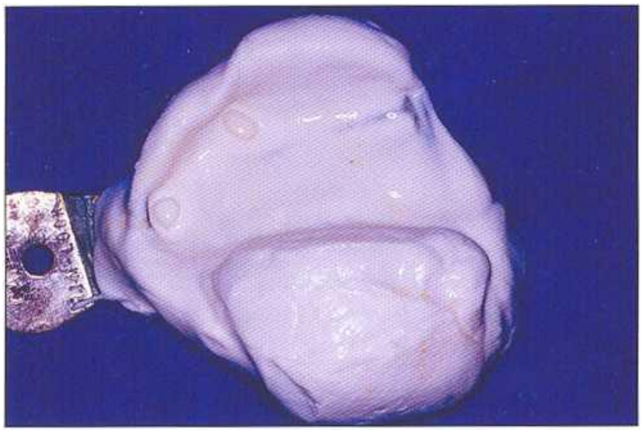


Fig 6-14 The preliminary impression should capture the periphery and carry into the defect 3 to 4 cm. This can be accomplished using a viscous alginate without need for injection of material or modifications to the stock tray. The surgical defect should not be blocked with gauze material prior to this impression.

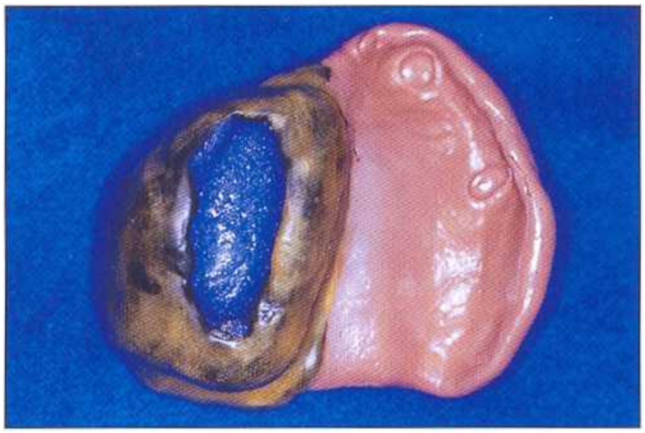


Fig 6-15 The defect impression has been functionally generated with impression wax over compound.

Final impression

The custom acrylic resin tray should extend 2 to 3 cm into the cavity. It should extend beyond the scar band and superior to the cut edge of the hard and soft palates, leaving space for 5 to 8 mm of compound to add to the surgical site. There may be cast undercuts within the surgical cavity, which must be blocked out or reduced from the tray before the impression. If these are not removed, the tray may be locked into these areas on the master cast. It is possible to make the tray hollow in the bulb area, thereby reducing weight and the tendency of the tray to dislodge due to gravity.

The remaining palate should be impressed first. The borders and cut edge of the palate should be border molded and then impressed with a definitive impression material. Performing this initial step creates a stable tray for the addition of the cavity impression. Compound should be added incrementally to the periphery of the surgical side of the prosthesis. The tray should be supported diagonally against the residual palate or alveolus so as not to rotate the tray into the cavity. With each increment of compound, the patient should go through swallowing and head movements. If any movement of the tray occurs, this area should be cut back and re-adapted before moving to the next area. The cavity is convex from inferior to superior. At the height of the convexity, the cavity walls begin to turn toward the center of the cavity. At this point the superior aspect of the prosthesis bulb should terminate. Superior extension beyond the greatest convexity' adds weight to the prosthesis but adds no retention. An exception to this rule is at the junction of the oral cavity and surgical margin of the prosthesis. The prosthesis should have some height to allow any liquids that express between the prosthesis and the tissues to travel along this same space by gravity back into the oral cavity. This can require a height of 1 to 1.3 cm. Another exception involves contacting the remaining bony walls of the maxillary sinus. When the walls remain and have been resurfaced with the split-thickness skin graft, there should be an attempt to capture those walls in the impression both peripherally and even as they turn toward the center of the cavity. These lateral and posterior bony walls can offer support against superior displacement during swallowing and mastication (see Figs 6-3 and 6-4).

Following the use of compound, an impression wax can be placed over the compound surface (Fig 6-15). The surgical side of the impression can be dipped quickly into a hot-water bath and then placed into the mouth. The area should be border molded again. Thin areas in the wax

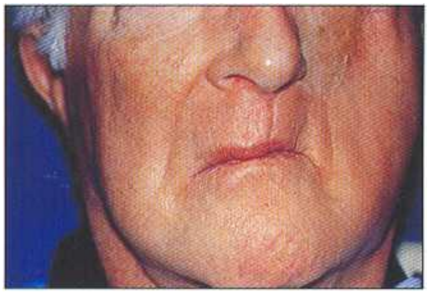


Fig 6-16 the patient has considerable loss of facial form due to a maxillectomy to the midline and to the floor of the orbit. His cheek was reconstructed with a microvascular free flap.

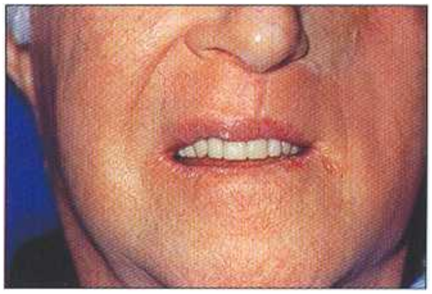


Fig 6-17 Full support of the lip and face was not possible due to contraction of the cheek that unseated the prosthesis. Considerable tooth display is also evident.

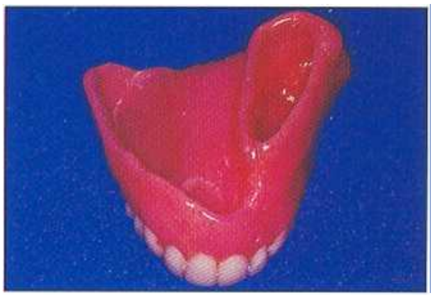


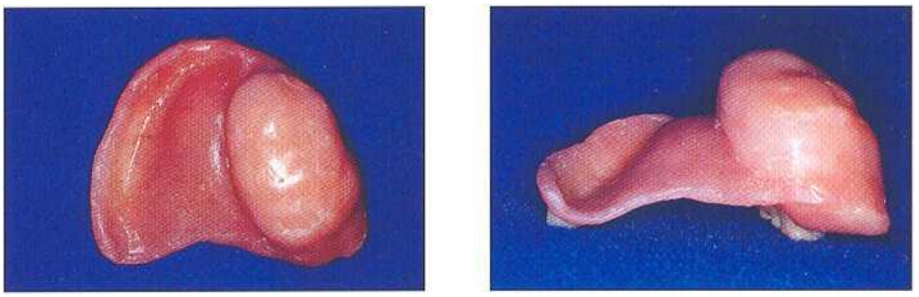
Fig 6-18 The lateral denture border is narrowed and the left arch is in crossbite.

will denote areas of pressure, which can be relieved in the compound impression and additional wax placed to repeat the procedure. A posterior palatal seal can also be placed. Because of the large wax surface area, the boxing of the impression is more easily accomplished with plaster and pumice.

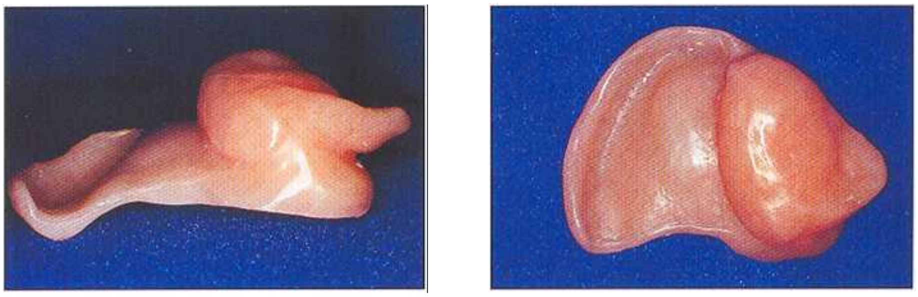
Jaw relationship records

Maxillectomy patients have loss of facial contour on the surgical side proportional to the amount of bone that is resected. The inferior portion of the maxillary bone and the alveolus support the lip. Infrastructure maxillectomies have minimal facial disfigurement. As the surgical defect includes the middle and superior portions of the maxillary bone at its junction with the zygomatic arch, the middle third of the face contracts (Figs 6-16 to 6-18). Finally, if the floor of the orbit is resected, the globe is also displaced. Often the maxillary resection crosses the midline, and if the nasal spine is resected, the nose is unsupported. There is a desire to use the obturator prosthesis to support the facial tissues. Unfortunately these tissues are fibrotic and can only be minimally displaced by the prosthesis border. Trying to push the contracted tissues into their preoperative position can cause overextension of the prosthesis borders. This creates considerable dislodging force on the prosthesis as the tissues rebound. The prosthetic support of the face is limited by the amount of retention that can be achieved from the residual palate and undercuts within the defect cavity. When an individual has an infrastructure maxillectomy (alveolus and sinus floor only) that does not cross the anterior midline, the lip and cheek can be easily supported by the dentition of the obturator prosthesis. As more of the maxillary bones are resected, however, tooth position and the flange of the prosthesis must be placed palatally due to tissue collapse. Attempting to maintain the dentition in its normal position will cause dislodging forces. There may be some scarring of the lip at the suture line that disrupts the normal drape of the lip, often requiring accommodation by changes in the occlusal plane and tooth position. Normal prosthetic landmarks cannot be used to position the dentition.

Processed record bases are ideal for jaw relationship records for the maxillofacial prosthetic patient. Because of the missing structures and unusual reconstructions, prosthetic retention and stability arc greatly compromised. Blocking out routine undercuts and the undercuts within the surgical area adds to the instability of the conventional record base. In the obturator cast, the undercuts are at the periphery of the prosthesis. Blocking out these undercuts will result in a trial base that does not extend to the periphery of the defect. After these blockouts, it is possible to have a trial base that makes no contact with the surgical side of the face. There will be no retention of the prosthesis except for the adhesive on the hard palate. The prosthesis will fall into the oral cavity

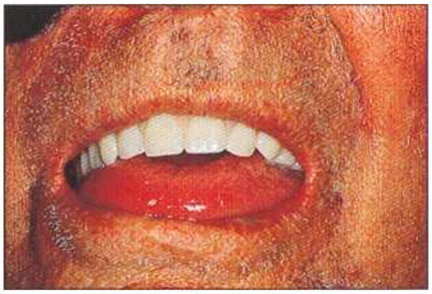


Figs 6-19a and 6-19b Conventional blockout of a trial base for a maxillectomy patient.



Figs 6-20a and 6-20b Processed record base for the same patient in Fig 6-19. The increased peripheral extension is evident.

Fig 6-21 The patient is using his tongue to support the conventional trial base during try-in. Evaluation of esthetics and occlusal plane is difficult due to lack of retention and stability.



when attempting to establish the occlusal plane and rotate into the defect when attempting the centric relation record. Without maximum extension of the record base, one cannot determine the optimal position of the teeth to support the lip and cheek. A processed base will reveal the optimal retention of the obturator prosthesis before addition of teeth. It is quite common to find that retention becomes worse as the wax rim is added in its preoperative position. If retention is decreased as the wax rim is added, the position of the rim must be modified to re-establish retention. A compromise must be reached between tissue support and prosthesis retention. Often the lip is scarred and contracted, creating too much or too little tooth display. Having the processed base allows the clinician to try different tooth positions to optimize speech, esthetics, and retention at the try-in appointment. It is important that the patient and clinician understand what can be accomplished prior to the insertion appointment (Figs 6-19 to 6-21).

The vvaxup of the processed obturator base can be solid in the.area of the bulb and hollowed before jaw relationship records. When waxing the prosthesis, one should recreate the palatal contours on the surgical side to be identical to the contours on the remaining hard palate. The bulb

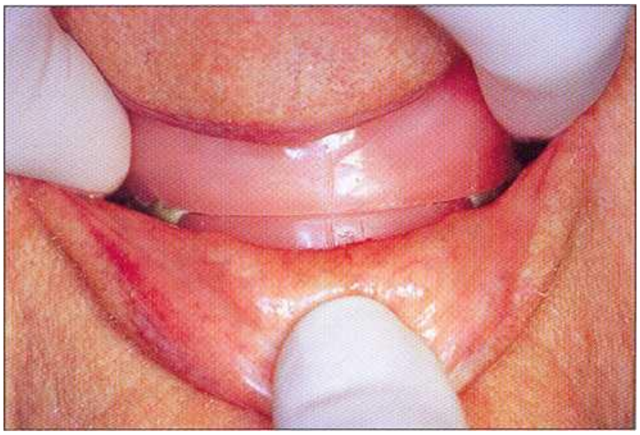


Fig 6-22 If the maxillary obturator base must be manually supported during jaw records, the mandibular prosthesis cannot be stabilized. A processed base will improve mandibular prosthesis stability.

can be processed hollow by waxing the external periphery of the bulb portion several millimeters thick and pouring a stone core through the back of the master cast or creating a stone core in the cope of the flask, in which case there will be a hole in the palate after processing. This hole in the palate must be closed later with a lid on the palatal surface. If the bulb is processed solid, the temperature should be below 165°F for approximately 15 hours to avoid porosity.

The jaw relationship appointment should progress as a routine denture appointment. Remount casts will be required for the processed bases. The usual parameters of speaking space and appearance should be considered for establishing vertical dimension of occlusion. The maxillary anterior rim should be placed at the wet-dry line of the lower lip. There should be an attempt to displace the contracted lip to achieve appropriate position of the rim; however, if the prosthesis begins to lose retention, the wax rim will require reduction on the facial aspect. Compensation for the contracted lip and cheek is often necessary on the surgical side, and it may be necessary to gradually create a negative horizontal overlap or end- to-end occlusion extending from the midline to the posterior dentition. Tap closure may be a problem due to contracture and shortening of the upper lip. One may elect to decrease the vertical dimension of occlusion slightly to compcnsate for poor lip closure, but the decrease may result in tongue or lip biting on the nonsurgical side of the mouth. Therefore, one should attempt to improve lip closure by buccolingual tooth position rather than a severe decrease in vertical dimension.

The centric relation recording material should be selected by clinician preference. As more of the maxillary arch and palate are resected, the greater the instability of the maxillary base. A processed base should also be considered for the edentulous mandible. When making the centric relation record, the clinician must manually stabilize the maxillary prosthesis, so he or she is not able to stabilize the mandibular prosthesis (Fig 6-22). Having a processed mandibular base can compensate for the inability to manually stabilize the base. Both prostheses should be retained with adhesive during the jaw relationship and try-in appointments. The maxillary base must be carefully watched for movement or shifting during the interocclusal record making. If the mandibular arch is partially dentate, the mandibular arch should be restored to allow full arch occlusion. This will assist in reseating the maxillary obturator under function and maintaining the correct vertical dimension.

At the try-in appointment, all records are verified. The patient and clinician will get an appreciation for the tooth position and tooth display.

For the patient edentulous in both arches, a cuspless tooth allows freedom to create a negative horizontal overlap on the surgical side of the arch without having to create it on the nonsurgical side. A clinical remount should be performed. Because these are processed bases, a laboratory remount can be performed after processing to correct errors; a clinical remount is not needed at insertion.

The final palatal contours should be evaluated at the try-in appointment. It is likely that the contours are not symmetric because they were created arbitrarily on the surgical side of the palate with few visible landmarks at the initial waxup of the base. The vault may be too high or too flat. It is often easy to detect the asymmetry by sweeping the thumb across the palate from the cusp tips on one side of the arch to the cusp tips on the other side. Place wax or reduce resin until the palate is symmetric. Finally, pressure-indicating paste can be streaked across the palate from right to left. Seat the prosthesis and have the patient swallow and count. Where the tongue makes contact with the palate, the contact can be read in the pressure-indicating paste. Heavy areas should be reduced and the entire palate checked again. Wax may need to be added in the palate where there is no contact. If the patient lisps, air is escaping laterally from the tongue. The patient may be given water to wet the mouth slightly and asked to count again. Water will likely express out the side of the mouth where the tongue is not making contact, and the pressure-indicating paste will likely be thicker in this area. Wax should be flowed along the premolar and canine areas on that side of the palate. With repeated adjustments and palatograms, more even contact will be observed on the entire palate after swallowing and speaking. Because the teeth are positioned palatallv due to facial contracture, they may impinge on the tongue. Sometimes it is necessary to reduce the width of the occlusal table on the surgical side to allow for tongue space. If the palatogram reveals a heavy contact against the palatal surface of the teeth, the occlusal table should be reduced. This palatal refinement should be incorporated in the final prosthesis when the teeth are processed to the baseplate. The prosthesis can be processed at a lower temperature than that used to process the base. The clinical significance of the distortion created with multiple processing of the resin is negligible.

After deflasking, the processed dentures can be replaced on the remount casts and a laboratory remount performed. The clinician may place a lid on the obturator prosthesis or may insert the prosthesis with the bulb open for several days until all of the adjustments are performed. Many clinicians choose to leave the bulb open. For diagnostic purposes, the superior portion of the bulb can be closed with a wax lid for several days after delivery. The patient can then make the choice between a closed or open obturator. Patients who exhibit particular problems during the interim phase may need more adjustments to satisfy their speech and swallowing requirements. Placement of the lid too soon may preclude adjustments without perforating the bulb.

Insertion

At insertion, the prosthesis should be evaluated for pressure areas as described for interim pros- theses, including pressure-indicating paste for the residual palate. The bulb portion should be checked for functional pressure areas with a tissue-conditioning material of contrasting color.

Instructions

Patients should continue to wear the maxillary prosthesis or the interim prosthesis at night because sinus secretions and saliva cannot be managed at night without it. If the prosthesis is removed overnight, the soft tissue periphery of the surgical site will change due to tissue edema, and patients will report that it often requires an hour of wearing the prosthesis in the morning before it fully seats into position.

Mastication is also often difficult for patients with large surgical defects and must be accomplished on the nonsurgerv side of the arch. Patients soon learn the limitations of their diets. Most require adhesives to secure the prosthesis and should be taught how to use them.

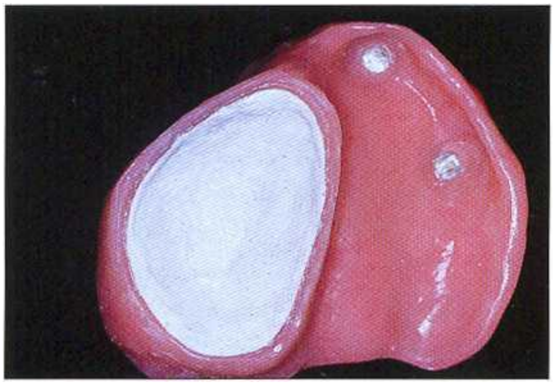


Fig 6-23 A stepped finish line is used on the periphery of the bulb, and plaster and pumice are used to create the shape for the lid.

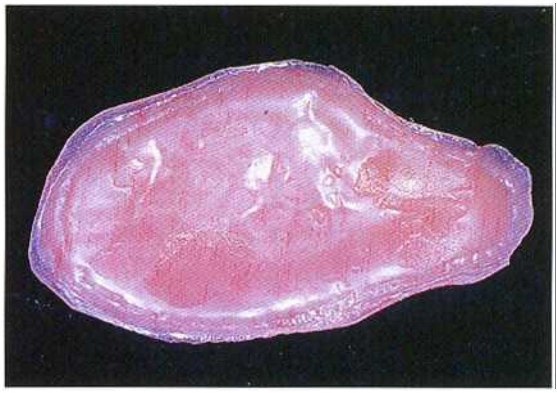


Fig 6-24 A Triad lid is cured over the plaster and pumice. The stepped finish line is visible at the periphery of the lid.

Lid fabrication of hollow obturator prostheses

Obturator prostheses are hollow to reduce the weight on the surgical side. But hollowing of the obturator can create spaces in the internal aspect of the bulb that are difficult for the patient to clean; therefore, a bulb that is left open must be symmetrically concave internally and wide enough at the superior opening for a patient to place a cleaning brush. Placing a lid on the bulb allows hollowing of the bulb into the alveolar area and into any unusual lateral undercuts. Any weight created by the lid is usually offset by hollowing a greater area inside the bulb.

Many methods have been described for sealing a lid to the bulb. The clinician should avoid methods that contaminate the acrylic resin (eg, melted sugar) or incorporate foreign bodies into the prosthesis (eg, wire mesh) to support the lid. Several methods were tested that avoid these conditions, and all were found to be satisfactory (Paprocki et al, 1990). The easiest and least time- consuming method uses a processed acrylic resin base with a Triad (Dcntsply, York, PA) lid. After hollowing, a stepped finish line is placed at the periphery of the bulb with a No. <S round bur, avoiding undercuts. Wet cotton rolls can fill the majority of the bulb, and the remainder is filled with plaster and pumice, creating a convex surface (Fig 6-23). Foil is adapted to the plaster and beyond the margins of the stepped finish line. A spot of glue can be used to stabilize the foil. A sheet of Triad is cut to fit slightly beyond the foil margins and adapted with a cotton-tip applicator to the pumice and the finish line (Fig 6-24). After curing in the light unit, the lid is finished to the edge of the finish line. The plaster is removed and the lid and the finish line are cleaned with monomer. A thin strip (2 mm wide) of sheet Triad is positioned on the finish line. The lid is seated and compressed with finger pressure. A cotton-tip applicator with monomer is used to push the expressed Triad over the edge of the lid. The entire prosthesis is placed in the curing unit. It is finished and polished to the finish line.

No matter what method is used to seal the bulb, the seal should be tested in a water pressure pot. Place a weight on the finished prosthesis and bring the water to 30 psi for one minute, then observe the hollow bulb for water and shake the prosthesis. Water that leaked into the bulb should be visible. If water is in the bulb, continue to shake it until the water percolates from inside the bulb, out of the sealed area that is leaking. If water is visible in the bulb but no percolation occurs, place the prosthesis in a dry pressure pot for 30 seconds, then shake the bulb. This additional pressure should force water through the leaking area. Use a No. 8 round bur to drill a hole to open the leaking area. Another hole can be drilled in another area of the bulb. Compressed air should be used to clear out the water in the bulb. Seal both holes with a piece of Triad and repeat the curing steps and water test. Gel resin, rather that sheet resin, can be used but does not stay in position on the stepped finish line and does not evenly express around the margins of the lid. As stated previously, any method may be successful, but leakage cannot be determined until the seal is tested under pressure.

Troubleshooting the Obturator Prosthesis

Leakage into the Nose

Many patients eventually complain of nasal reflux and hvpernasal speech caused by escape of air. This may occur several months or even a few years after insertion of the prosthesis. In most cases, continued fibrosis in the tissues bordering the prosthesis is the cause. The prosthesis should be disclosed with a tissue-conditioning material, and the patient should perform functional movements. If swallowing and speech improve, the disclosing material should be evaluated for the area where the tissue conditioner is thickest. The speech can be tested by evaluating the *m* and *b* sounds and the word beat as described previously. The thickness of the material can be checked with an explorer. Most areas will be very thin, while other areas will be 2 to 3 mm or thicker. These thicker areas should be targeted for the reline procedure, often indicated in only 1 to 2 cm of the periphery of the bulb. This reline can be accomplished chairside with an autopolymcriz- ing or composite acrylic resin (Triad). The tissue conditioner should be removed. The area requiring reline should be cut back 3 to 4 mm in depth, and a heavy finish line is cut into the prosthesis bordering the area. The Triad reline material (sheet) can be cut to fit the reline area. The surface should be cleaned with methyl methacrylate monomer, and the reline material is positioned. The material can be arbitrarily shaped to resemble the previous tissue-conditioning material. This area should be dipped in a hot-water bath and taken to the mouth. After functional movements, the prosthesis can be removed. The excess material that flowed beyond the finish line margins can be cut away with a knife. This procedure should be repeated until no flash is present and the material has flowed smoothly to the finishline junction. The material is coated with the manufacturer’s air barrier coating and cured in the system’s curing unit. This procedure satisfies the patient’s chief complaint and requires minimal time. The surface can be highly polished, after which the finish line is imperceptible.

Hypernasal Speech

Patients may complain of hypernasal speech at follow-up visits. Disclosure of the bulb with tissue-conditioning material often reveals that the surface contact is adequate. In this situation, the prosthesis is adequately closed at the periphery, but the patient’s soft palate and pharyngeal closure mechanism are not functional. This may be a finding at the initial interim phase, or it may occur many months following surgery, as fibrosis of the soft palate progresses. Observation of the soft palate usually reveals that it is barely elevating on phonation and/or it is quite short in an anterior-posterior dimension. This condition is seen frequently when a portion of the soft palate was also resected due to a lesion located at the hard palate-soft palate junction. Relining of the prosthesis periphery will not alter the hypernasal speech. If there is adequate space to add a pharyngeal bulb to the posterior medial aspect of the prosthesis, this bulb can pass superiorly to the cut edge of the soft palate and extend into the pharynx. In this way, the minimally functional soft palate is bypassed by the pharyngeal obturator. The conventional obturator prosthesis will obturate the hard palate defect and the extension will obturate the nasopharynx.

The pharyngeal obturator extension can be arbitrarily shaped to extend into the pharyngeal opening over the soft palate with baseplate wax or with a heavy mix of tissue-conditioning material (Fig 6-25). The arbitrary addition can be used as a tray to carry a light wash of tissue-condition-

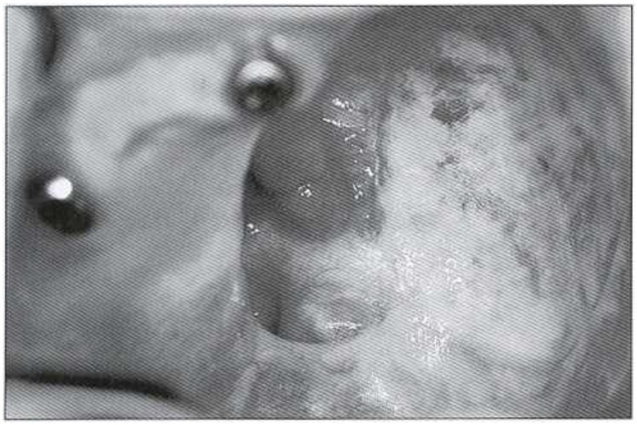


Fig 6-25 The pharyngeal extension to obturate a minimally functional soft palate is placed in the opening seen at the posterior medial edge of the hard palate. This patient's speech was improved with the pharyngeal extension, but he was often unable to maneuver the prosthesis into position. The pharyngeal extension was removed. This patient demonstrates augmented retention by placing ferrous copings on two retained teeth with magnets placed in the denture. These teeth have functioned for 10 years.

ing material for border molding. This pharyngeal obturator must also be shaped for optimal swallowing, head movements, and speech. This impression can be a diagnostic maneuver to determine if the obturator offers improvement in speech and if it can be tolerated and inserted by the patient. Some patients are unable to seat the prosthesis because of its unusual path of insertion. If this procedure is unsuccessful, the hypernasal speech cannot be prosthetically corrected.

Conclusion

The edentulous obturator patient has greater problems in retention, speech, and mastication than the conventional maxillary denture patient. While it seems obvious that these patients would benefit from implants placed in the maxilla, lack of suitable bone quality and quantity in the remaining arch and within the residual bones of the skull on the surgical side precludes widespread use of implants. Bone grafts and sinus lifts are usually needed in the remaining arch, but patients are often reluctant to undergo more surgery'. Adjuvant radiotherapy leads to increased implant failure in the maxilla, and implants placed within the surgical cavity are often not accessible through the oral opening for prosthetic restoration. In addition, implant cost is still prohibitive. Consequently, few patients have been able to benefit from implants. If clinicians have an option to maintain one or two maxillary teeth, these teeth should be maintained rather than rendering the patient edentulous. Although some teeth may not be adequately positioned to retain a conventional partial denture obturator prosthesis, they can become suitable overdenture abutments to be used in a coping/magnet system (Fig 6-25). Mandibular teeth should also be maintained so the patient is not functioning with a complete mandibular denture as well as an unstable obturator prosthesis. Finally, no matter what additional retentive elements may be employed, sound prosthodontic principles of using bony' undercuts, achieving maximum tissue coverage without overextension, and placing the dentition in harmony with the functional tissues are paramount for prosthetic success when treating the edentulous maxillectomy patient.

Reference

Paprocki GJ, Jacob RF, Kramer DC. Seal integrity of hollow-bulb obturators. Int J Prosthodont 1990;3:457.

Clinical Management of the Dentate Maxillectomy Patient

o Michael R. Arcuri, DDS, MS o

Thomas D. Taylor, DDS, MSD

Obturator prostheses for maxillary or combined maxillary and mandibular defects are frequently associated with problems that result from lack of retention and stability. These problems result in a traumatic functional occlusion and an inability to obtain acceptable oroantral or oronasal seal. However, when natural teeth remain, successful rehabilitation usually becomes more predictable. This chapter addresses the fabrication of obturator prostheses unique to dentate patients. The reader is referred to Chapter 6 for discussion of those considerations common to obturator fabrication for both edentulous and dentate patients and for detailed discussion of the management of the actual surgical defect, timing of the phases of treatment as they relate to the surgical defect, recommendations to the surgeon for maximizing the prosthodontic outcome following surgery, and other issues common to both dentate and edentulous maxillectomy patients. While this chapter's primary focus is on the dentate patient following ablative surgery for malignancy, the principles described apply equally well to dentate patients with maxillary defects that are the result of traumatic injury as well.

Due to the anatomic complexity of the mid- face and the nearly endless potential for surgical or traumatic defect size, shape, and location, characteristics of and treatment considerations for maxillary defects present an unlimited variety of possible configurations. Simplified classifications of these defects have been developed that may be helpful in categorizing the type of prosthesis design that will be necessary to treat the patient as well as to predict the most likely problems one might encounter in dealing with patients with different classifications of defects (Aramany, Parts I and II, 1978).

Preoperative Considerations

Preoperatively, the prosthodontist is concerned with four objectives, according to Desjardins (1977): psychological support of the patient, preoperative dental management, preoperative impressions, and suggestions for the surgeon. Psychological support of the patient is addressed in Chapter 1. The other objectives as they relate to the partially edentulous patient are discussed below.

Dental Management

The dental health status of the patient is an extremely important consideration for the prosthodontist when planning maxillectomy obturator management both pre- and postsurgically. Frequently, the need to proceed with ablative surgery does not permit ideal presurgical dental care. Within time limitations prior to tumor surgery, every attempt should be made to treat existing dental disease present in the patient’s mouth for two primary reasons. First, by treating active dental disease prior to surgery, the risk of emergency dental problems during the postsurgery healing period will be reduced, allowing a more complication-free recovery. Second, early treatment of dental disease will increase the likelihood that the remaining teeth will serve as adequate abutments for obturator and/or mandib- ulectomy prostheses.

A general principle that should be followed when dealing with a maxillectomy patient preop- eratively is to do everything that can be done in the time available to increase the potential postoperative health status and potential usefulness of the remaining teeth. When possible, referral of the patient to the dental hygienist for prophylaxis prior to surgery is recommended to improve patient comfort and to reduce the risk of tooth- related soft tissue problems during the early post- surgical period, when oral hygiene is likely to be limited and infrequently applied. Teeth that would normally be considered nonrestorable or of no value (such as maxillary third molars on the surgical side of the arch that were not removed as part of the tumor resection) may become extremely valuable abutment teeth for an obturator prosthesis, and teeth that might be removed under normal conditions as part of conventional prosthodontic therapy might prove beneficial as abutment teeth for an obturator. An example of this principle is the decision to maintain severely supraerupted posterior teeth that interfere with the plane of occlusion in routine prosthodontic rehabilitation. These teeth might become critical to the stability and retention of an obturator even though the occlusal plane has to be modified to accommodate them, precluding or severely compromising the replacement or restoration of opposing mandibular teeth. Decisions regarding remaining maxillary teeth in the maxillectomy patient may be affected by whether pre- or postoperative radiation therapy to the region has been planned. Generally, the potential risk of osteoradionecrosis resulting from dental treatment (or lack of dental treatment) in the maxilla is minimal and well worth the risk when weighed against the potential value of teeth as abutments for an obturator prosthesis. When time available for presurgical dental care is limited, priority should be given to treating carious lesions with excavation and provisional i zation with sedative interim restorations. Pulp exposures or teeth with potentially necrotic pulp chambers should have endodontic therapy initiated and medication placed beneath well-positioned provisional restorations. Gross scaling and limited prophylaxis should be performed if time does not permit complete treatment. As a general rule when dealing with a presurgical maxillectomy patient, all maxillary teeth that can be maintained should be. If it is determined at a later date that teeth must be removed, little has been lost and much might have been gained if those teeth prove useful.

Presurgical impressions

Presurgical impressions of both maxilla and mandible should be part of the routine management of maxillectomy patients. The resultant casts serve as a record of the presurgical state and may be referred to when designing and fabricating the obturator prosthesis subsequent to surgery. It is recommended that two casts be made of the maxillary arch before surgery. One is kept as a permanent presurgical record and the other may be used to fabricate the surgical obturator and the interim or postsurgical obturator prosthesis. For the latter, the cast may be duplicated as needed in the laboratory. It is critical that the presurgical impressions of the maxillary arch capture the full vestibular depth of the complete arch. The overextended soft tissue reflections of the vestibular area of the impressions will allow maximum extension of the surgical obturator into the defect area and will offer the greatest possible support for the surgical dressing. Design of the surgical obturator is discussed later in this chapter.

Surgical enhancements and suggestions for the surgeon

As with the edentulous patient, it can be generally stated that the prognosis for prosthodontic rehabilitation improves markedly as the size of

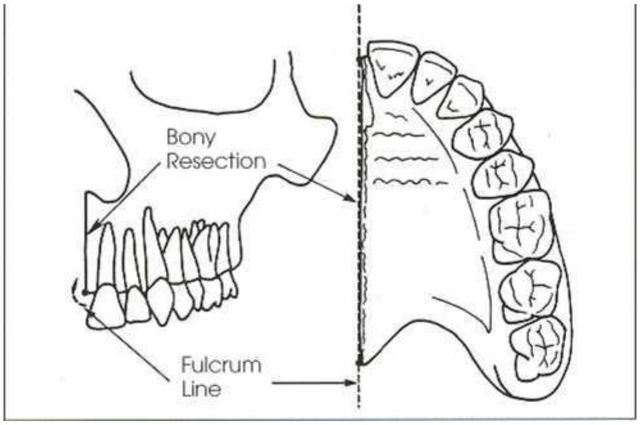


Fig 7-1 Classic hemimaxillectomy midline resection as seen on the bony hard palate. The fulcrum for tissueward displacement is along the line of bony resection. The fulcrum or rotation line for downward movement of the obturator due to gravity will tend to be through the retentive clasp tips of the most widely spaced clasps. In this situation, the most favorable points of retention would be on the mesial of the central incisor and the distobuccal of the third molar. Spacing the retentive arms at maximum distance from each other will tend to maximize the stability of the prosthesis when the mouth is open, and rests placed in the area of the premolars give maximum indirect retention. (Figs 7-1 to 7-3 reprinted with permission from Chapter 36 [Taylor et al], in: Thawley et al |edsj. Comprehensive Management of Head and Neck Tumors, ed 2. Philadelphia: Saunders, 1999.)

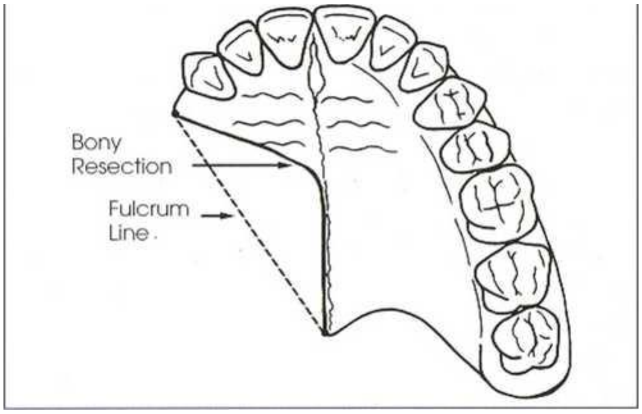


Fig 7-2 In this situation, the line of bony resection has preserved the anterior teeth on the defect side. A fulcrum line for tissueward displacement will occur, as in Fig 7-1, through the edges of the bony defect. Rotation away from the tissue base will occur around an axis through the two terminal clasp tips. The most effective placement of retention for this situation is to clasp the facial of the canine on the defect side and the distobuccal of the terminal molar, in this case the third molar. Indirect retention in the form of occlusal rests is best placed in the premolar area midway between the terminal clasps.

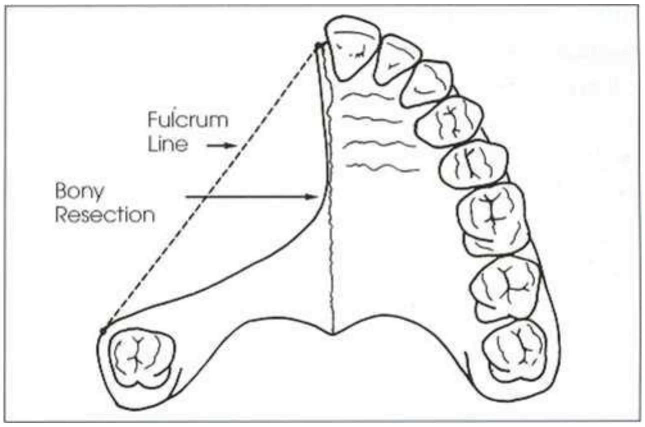


Fig 7-3 Representation of a maxillectomy that preserves the posterior alveolus on the defect side. Assuming that the obturator design in this situation includes rests and clasps on the two teeth closest to the defect (the right third molar and the left central incisor), the fulcrum for tissueward movement into the defect and downward movement away from the defect will be nearly identical through these teeth. An indirect retainer rest in the molar region of the nondefect side will effectively counteract downward movement of the obturator. A clasp arm placed in the molar area of the nondefect side will counteract tissueward motion of the obturator.

the detect diminishes. Put another way, it is the responsibility of the prosthodontist to communicate to the surgeon the prosthodontic advantages of maintaining as many of the alveolar processes and teeth as possible without compromising complete removal of the tumor. Whenever the traditional midline hemimaxillectomy can be modified to preserve alveolar process or, better yet, teeth on the surgical side, the prognosis of prosthodontic care improves dramatically because the functional fulcrum line shifts to a more favorable position (Figs 7-1 to 7-3). Another suggestion to the surgeon that will noticeably improve the prosthodontic prognosis is that the line of resection be made through the socket of an extracted tooth rather than attempting to cut between roots of adjacent teeth (Fig 7-4). Inferproximal cuts will result in loss of alveolar support for the tooth adjacent to the defect and can lead to the loss of the tooth postsurgicallv.

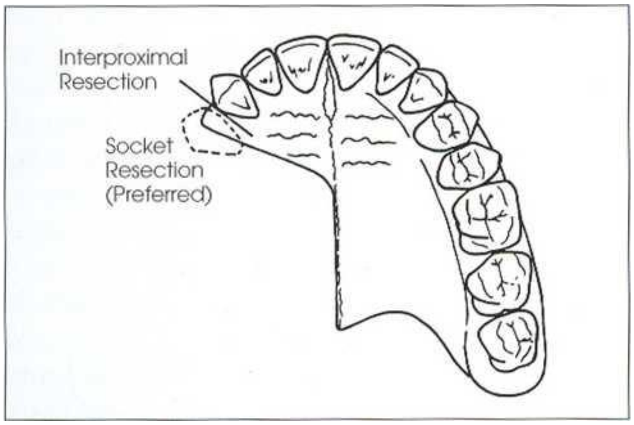


Fig 7-4 Schematic representation of the line of resection extending through the socket of an extracted first premolar. Placement of the line of resection through an extraction socket will preserve more adequate alveolar bone around the terminal tooth adjacent to the defect than a resection that is carried interproximally between teeth. If inadequate bone remains adjacent to the terminal tooth, its usefulness as a primary abutment for an obturator prosthesis is questionable. (Reprinted with permission from Chapter 36 |faylor et al], in: fhawley et al [edsj. Comprehensive Management of Head and Neck Tumors, ed 2. Philadelphia: Saunders, 1999.)

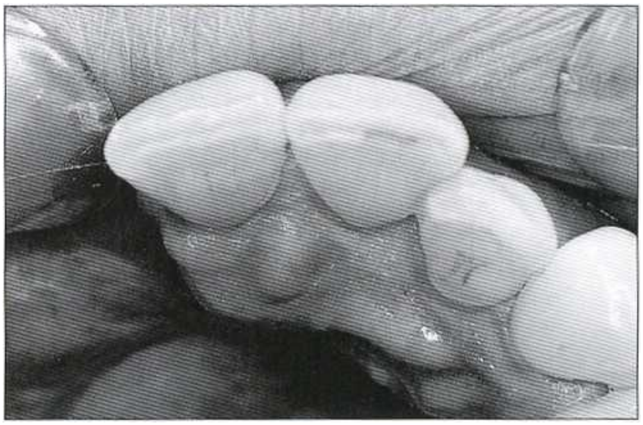


Fig 7-5 Example of a situation in which the maxillectomy resection was made between the central and lateral incisors. This resulted in a lack of alveolar bone adjacent to the remaining central incisor accompanied by increased mobility and lack of response to electrical pulp testing. The tooth was eventually extracted due to continually increasing mobility.

The tooth adjacent to the defect is critical as an abutment for the obturator prosthesis, and its alveolar support must be maintained. If the alveolar support of the remaining tooth immediately adjacent to the defect is not adequate, it should be considered for extraction prior to the design and fabrication of the definitive obturator prosthesis (Fig 7-5). Obviously, it is preferable to avoid the need for additional extractions subsequent to the initial loss of teeth and maxilla.

The Surgical Obturator Prosthesis

Detailed management of the surgical defect is presented in Chapter 6. Those considerations specific to the dentate patient are presented here.

Historically there has been some disagreement as to the value of the surgical obturator. The surgical obturator is not a requisite for maxillectomy surgery but does offer distinct advantages for the patient when compared with surgery performed without an obturator. The surgical obturator, placed at the time of tumor resection in the operating room, provides the surgeon with an anatomically accurate, stable, clean scaffold upon which to support the surgical dressing that, in turn, supports the facial flap and keeps pressure on the skin graft placed over the denuded internal surface of the facial flap. It provides a barrier between the surgical dressing and the oral cavity so the patient does not feel the extent of the defect or dressing with his or her tongue during the initial healing period. Surgical obturators also allow patients to take nourishment without a nasogastric tube, enable the patients to speak normally, and minimize the initial feelings of loss that occur when patients realize the extent of their surgical defects. In most cases, surgeons who elect not to place a surgical obturator do so because they do not have one available, because they are unaware of the benefits, or because surgical obturators they placed in the past could not be made to work.

Surgical Obturator Design

The design of the surgical obturator should be based upon the understanding that it is actually a stent rather than an obturator. It should also be designed and fabricated with the understanding that it cannot be tried in and adjusted preopera- tively but must fit and function as intended without adjustment. The purpose of providing a scaffold or foundation for the surgical dressing should be understood and the design and fabrication based upon that purpose. The surgical obturator is normally fabricated from polymethyl methacrylate resin of either the heat or autopolymerizing type. It is most commonly fabricated in clear resin to facilitate visualization of the underlying tissues at the time of placement and during the initial healing period.

The need to retain the surgical obturator in place for an extended period of time without removal makes maximum retention a necessity. Wire clasps will usually not provide adequate retention for the surgical obturator and may, at times, actually make it more difficult to place. Similarly, the addition of teeth to the surgical obturator is both unnecessary and contraindicated. The surgical obturator will be replaced very soon after it is placed, usually in about a week’s time, and the presence of teeth on the obturator may complicate its placement, particularly if the obturator does not seat completely with the surgical packing in place and the occlusion on the teeth of the obturator is unacceptably heavy. If immediate postsurgical esthetics is of overriding importance to the patient and/or the family, or if the surgical obturator is anticipated to serve as the postsurgical or interim obturator, anterior teeth may be added to the prosthesis. If it is also to be used following pack removal as the postsurgical obturator, it is appropriate to add clasps to the surgical obturator, but for the dentate patient it is usually unnecessary to fabricate the surgical obturator with clasps unless the prosthodontist anticipates such conversion. The surgical obturator may be fabricated with holes placed in the periphery to permit suturing to the borders of the defect, for circumzygomatic wiring, or for interdental wiring or suturing. Frequently, the surgeon will prefer to retain the surgical obturator with one or more palatally placed bone screws. Regardless of the method of retention used, how the obturator is retained is the surgeon’s decision, and the surgical obturator should be fabricated with his or her desires in mind.

If one assumes that the final lines of resection may not be determined until the time of surgery, the prosthodontist must design the obturator for use regardless of the final line of resection. There are two basic approaches that can be taken when designing a surgical obturator for the dentate patient. One can fabricate the obturator according to the most conservative line of resection, which will still allow the obturator to be used for larger resections with the understanding that surgical dressing may be needed to fill the space between the obturator and the final line of resection. This method allows the surgeon to utilize the obturator regardless of the size of the defect and docs not require the surgeon (or the prosthodontist) to perform intraoperative adjustments to the obturator (Figs 7-6 and 7-7). 'Flic other option is to design and fabricate the surgical obturator for the most extreme surgical resection, thereby making it fit best in the worst case situation. With this approach the surgeon must be willing and able to modify the obturator to accommodate teeth that are not resected but have been removed from the cast during obturator fabrication. Another option with this type of design is to have the prosthodontist available at the time of surgery to perform the modifications. While it may be standard procedure at some treatment centers to have the prosthodontist present during surgery, it is frequently unrealistic for the prosthodontist to be present for the operation only to adjust the surgical obturator if the resection varies from the presurgical plan. Regardless of which design alternative is used, it is the surgeon’s preference that dictates the design and placement of the lines of resection on the cast. Similarly, it is the surgeon’s decision as to what type of retentive mechanism is built into the surgical obturator. When the method of retention is in doubt or if the surgeon wishes to have several options available, the obturator should be fabricated with multiple holes in the periphery to permit inter-

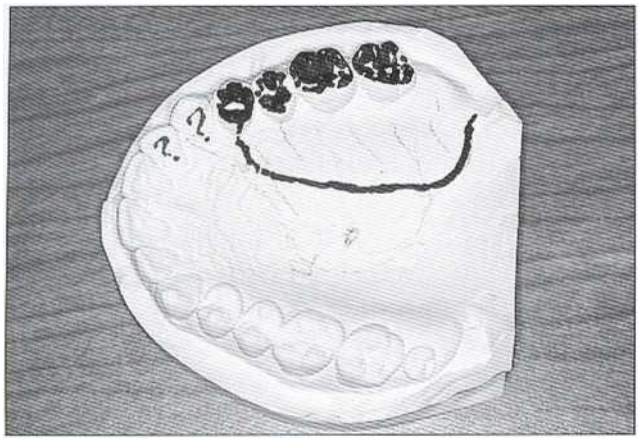


Fig 7-6 The surgeon has outlined the most likely line of resection for the anticipated maxillectomy. There is some question as to whether the canine and lateral incisor might also have to be sacrificed if the procedure warrants wider surgical margins. In this case, the surgeon must decide whether to have the surgical obturator fabricated to the more conservative line of resection, which would allow its use without modification even if the resection is more radical, or to have the obturator fabricated assuming that the canine and lateral incisor will be lost. If the latter, the surgeon must be prepared to modify the surgical obturator to fit around the teeth not removed or the prosthodontist will have to be available in the operating room to make this adjustment. Either way, the surgeon must determine the extension of the surgical obturator.

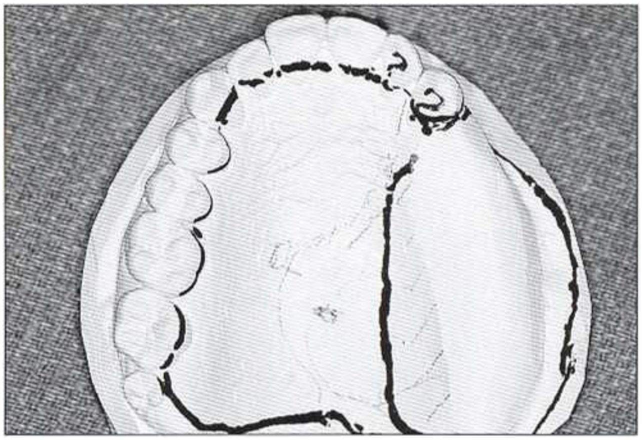


Fig 7-7 The surgeon has elected to have the obturator fabricated to the most conservative line of resection, which will allow its use regardless of how much more extensive the final surgical defect actually is. The obturator fabricated to this outline can still be used to support the surgical packing if the canine and lateral incisor are both lost.

dental wiring, suturing to the defect borders, or circumzygomatic wiring. Holes approximately 2 mm in diameter and spaced every centimeter around the periphery should be adequate. If palatal screw retention is a possibility, those holes may be provided as well. Once again, the surgeon must determine the position of the palatal screw holes, as some prefer one midline screw that will anchor into the vomer while others prefer to avoid splitting the vomer and utilize nonparallel screws in the palate lateral to the midline. The surgeon should diagram the position of the screw holes on the cast or should be prepared to drill such holes at the time of surgery.

Surgical Obturator Fabrication and Use

Fabrication of the surgical obturator in the laboratory must be carefully supervised by the prosthodontist. Whenever possible, the prosthodontist should be the one to perform the cast surgery after consultation with the surgeon regarding the most likely resection outline (Fig 7-8). The teeth in the area of resection are removed and the surrounding alveolar process in the planned defect area is reduced approximately 2 mm. This additional reduction is important to allow adequate space for the surgical obturator intraorally without coming into premature occlusal contact with the opposing dentition during function. Only the alveolar process is reduced to ensure a lack of occlusal interference. The palate and buccal surfaces of the cast are not reduced in this manner.

Following the cast surgery, substantial interdental and soft tissue undercuts are blocked out and the cast is duplicated. The surgical obturator is then waxed and processed on the duplicate cast. This allows one to retrieve the processed obturator and to adjust it for ease of seating on the original cast prior to polishing and gas sterilizing for delivery to the operating room. Another option is to fabricate the surgical obturator directly

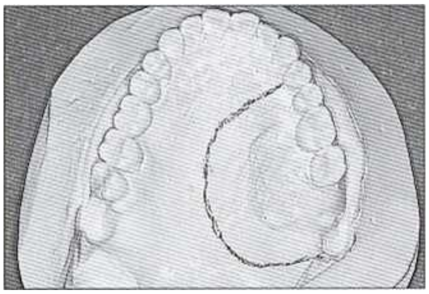


Fig 7-8a Outline of anticipated line of resection drawn on preoperative cast.

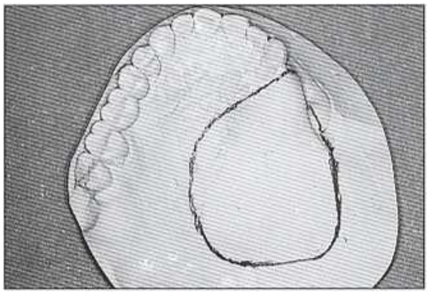


Fig 7-8b The teeth have been cut away and the alveolar process reduced in the defect area in preparation for waxing the surgical obturator.

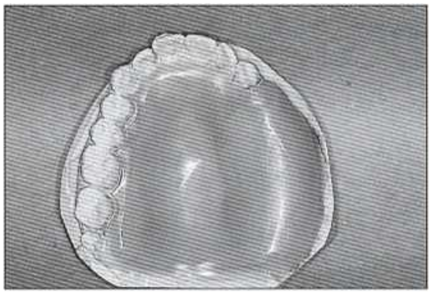


Fig 7-9 Waxup of the surgical obturator prior to processing. Two thicknesses of baseplate wax should provide adequate strength without excessive bulk.

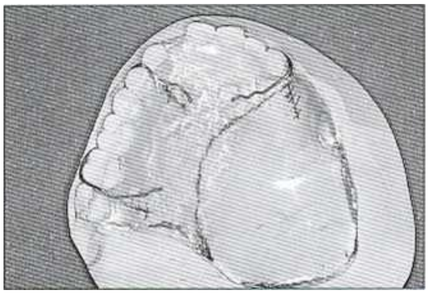


Fig 7-10 Surgical obturator has been adjusted and finished on the original cast. It is now ready for sterilization and use. Note that the obturator does not extend vertically into the anticipated defect area. This allows maximum adaptability if the margins of surgical resection are changed. The purpose of the surgical obturator is to support the surgical pack or dressing during the immediate postoperative period.

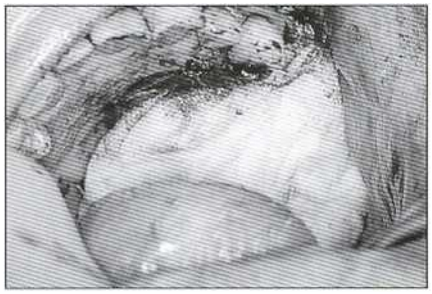


Fig 7-1 la Intraoral view of the surgical packing after placement into the maxillectomy defect.

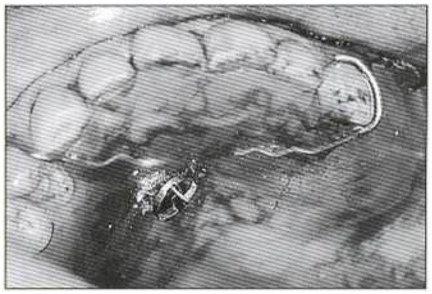


Fig 7-lib The surgical obturator has been placed with a palatal bone screw to support the packing.

on the cast with autopolymerizing resin. This will tend to reduce the amount of processing distortion requiring adjustment.

Two thicknesses of baseplate wax are adapted to the duplicate cast as outlined and serve as the pattern for the surgical obturator (Fig 7-9). For the dentate patient, the waxup should contact all remaining teeth up to their height of contour but without approaching the area of occlusal contact. Having the cast articulated with the mandibular cast is beneficial for the waxup. The wax is carried to the height of contour of the teeth to ensure that there is an adequate thickness of resin to support interdental wiring if it is to be used. If clasps are added, it is important to place them in areas that will not interfere with seating of the obturator during surgery nor interfere with the occlusion of the opposing teeth. Following processing and retrieval, the obturator is adjusted to ensure ease of seating on the original cast and trouble- free placement at the time of surgery (Fig 7-10). 'Fhe completed surgical obturator is sterilized and inserted following resection and placement of the surgical dressing (Figs 7-11).

As with the edentulous patient, the surgical obturator and dressing will be removed approximately 1 week postoperatively. This procedure may take place in the hospital, the surgeon’s office, or, ideally, in the prosthodontist’s office. The latter is frequently preferred to facilitate the immediate placement and modification of the post- surgical obturator.. Regardless of where the pack removal takes place, it is beneficial to have both the surgeon present to evaluate wound healing and the prosthodontist present to provide post- surgical obturator service.

The Postsurgical Obturator Prosthesis

Postsurgical Obturator Design

Following surgery, the extent of the surgical defect and the number of teeth lost are no longer subject to change. At this time the original cast that was modified to fabricate the surgical obturator is evaluated for suitability as a master cast on which to fabricate the postsurgical obturator. If the cast surgery was more conservative than the actual procedure performed on the patient, the cast should suffice for creation of the base portion of the postsurgical obturator. If the actual surgery was less aggressive than that performed on the cast, it will be necessary to use the remaining unaltered cast made from the preoperative impression. A duplicate of the preoperative cast will also suffice. Occasionally, it may be necessary to make a new impression at the time of surgical pack removal. If this is the situation, it is recommended that the time between pack removal and the placement of the postsurgical obturator be kept to a minimum. Tissue contraction and edema in the defect will quickly alter the shape of the defect, making it extremely difficult to insert the obturator.

Postsurgical Obturator Fabrication and Use

The postsurgical obturator prosthesis is customarily fabricated of resin with wire retentive clasps in strategic locations. If adequate retentive undercuts are not present on the abutment teeth, they may be created by modification of tooth structure or added with composite resin. Substantial retentive undercuts and multiple clasps may be required to retain the postsurgical obturator with wire clasps, depending upon the location and size of the surgical defect and the position and number of abutment teeth available. As a general rule, clasps will be most effective in resisting downward displacement of the obturator if they are located as close as possible to the defect and at maximum distance from each other (Fig 7-12). This is somewhat in contrast to the recommendation of Desjardins (1978) that clasps should be placed as close to and as far from the defect as possible. Such a configuration might not necessarily place clasps as far apart as possible and might, in fact, place a clasp on a tooth that serves as an indirect retainer, rendering the clasp nonfunctional.

As a general rule, the resin base portion of the obturator prosthesis should contact the axial surfaces of all remaining teeth whenever possible (Fig 7-12). While maximal tooth contact makes the prosthesis more difficult to adapt to the teeth initially, it provides maximum stability and has the greatest potential for distributing the forces generated by the obturator to the greatest number of teeth and the broadest area of residual palate possible. This general principle of broad coverage and maximum contact on available tooth surfaces should be carried over to the design for the definitive obturator prosthesis. Maximum support and stability from all available soft and hard tissues must be utilized to dissipate the forces generated by the obturator prosthesis.

As with the surgical obturator, the addition of teeth to the postsurgical obturator should be limited to satisfying esthetic needs and assisting in speech production. Occlusal function on the obturator should not be encouraged during the early healing period because it will likely result in movement of the obturator into and out of the defect with resultant irritation and abrasion of the tissues contacting the obturator.

At the time the surgical obturator and packing are removed from the defect, the postsurgical obturator should be available to place immediately (Fig 7-13). When the postsurgical obturator has been fabricated on a preoperative cast with arbitrarily drawn and carved extensions in the defect area, it is assumed that extensive immediate modification of the obturator will be necessary to make it functional. As described in detail in Chapter 6, modification of the obturator in the area of the defect is critical to its function as well as to the comfort of the patient.

It is difficult at times to maintain the nondefect portion of the prosthesis in its proper relationship to the supporting teeth and residual palate

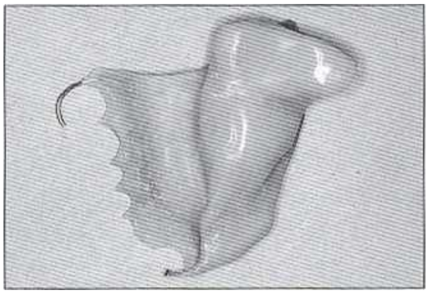


Fig 7-12 Superior view of an interim or postsurgical obturator prosthesis prior to placement. Note that the obturator contacts all remaining teeth for maximum stability and the wire clasps are placed at the extreme opposite ends of the residual dental arch.

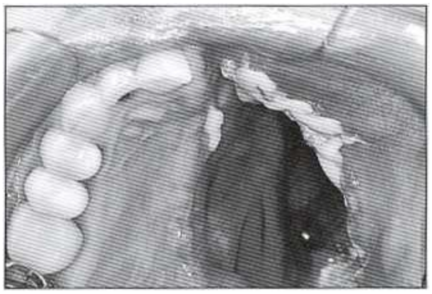


Fig 7-13a View of the maxilla **1** week following maxillectomy.The surgical obturator and packing have just been removed. Note the white, irregular appearance of the split-thickness skin graft along the lateral aspect of the defect. This appearance is normal for a skin graft that has been recently placed.

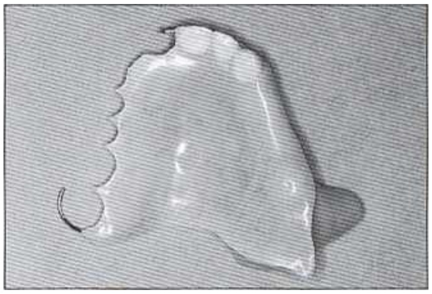


Fig 7-13b Oral surface of the obturator prior to placement. Note that only the anterior teeth have been added to the prosthesis for cosmetic purposes. An occlusal stop has been placed in the region of the second molar to facilitate correct repositioning of the prosthesis during additions and modifications to the bulb portion of the obturator.

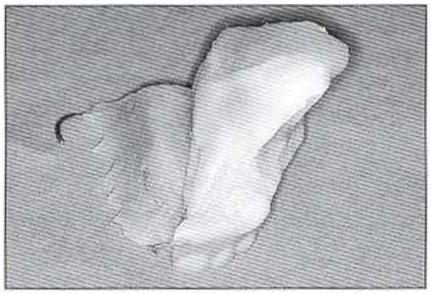


Fig 7-13c Tissue-conditioning material has been added to the obturator to more closely adapt the obturator bulb to the walls of the defect.

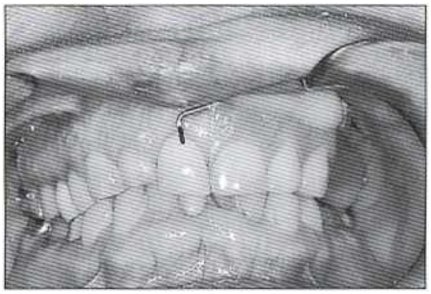


Fig 7-13d The interim obturator prosthesis following completion of the initial fitting session. Note the presence of the single occlusal contact in the second molar area of the defect side. This will assist in maintaining the obturator in its correct position.

during obturator modification and reline procedures. There is a tendency for the obturator to sag under its own weight and to resist complete seating following additions of tissue-conditioning or impression material. Stabilizing the obturator during the relining procedure is an open-mouth procedure because adaptation of the defect walls to the obturator when the teeth arc together cannot be obtained. A technique that has proven useful in such situations for patients with remaining mandibular teeth opposing the defect area is to provide a single posterior occlusal stop on the oral surface of the obturator (Fig 7- 13b). With this occlusal stop, the obturator can be inserted and the patient instructed to occlude the teeth to scat the obturator completely during impression or reline procedures. In this way the obturator can be maintained at its original level. It also provides support for the obturator to resist downward rotation during function, thereby reducing the retentive load on the maxillary abutment teeth. The risk of this technique is that downward pressure on the obturator caused by tissue shrinkage in the defect may bring this lone occlusal contact into premature occlusion. Careful evaluation of the soft tissue contact within the defect with pressure-indicating paste or resilient material on a regular basis is necessary during the healing period to avoid this problem.

The patient should be instructed in the insertion and removal of the prosthesis, and familiarity and comfort with these procedures is extremely important. Unlike conventional dentures, the obturator is usually worn during sleeping hours and should only be removed for brief periods while cleaning the defect and the prosthesis. Extended periods without the obturator may result in difficulty reinserting the prosthesis. Constant wearing of the obturator necessitates the application of proper hygiene to both the prosthesis and the defect. A soft toothbrush is usually the best instrument for cleaning the prosthesis, and routine dental hygiene aids should be recommended for the remaining natural dentition. During the postsurgical or interim healing period, when it is likely that tissue-conditioning and/or soft reline material is present on the bulb of the obturator, the patient should be instructed to avoid effervescent types of denture cleansers as they will tend to cause blistering of the lining material. A soft brush and hand soap should be adequate for cleaning the prosthesis during this phase of treatment and may be recommended for the definitive prosthesis as well.

Regular recall visits of approximately 1 week initially and then 2 weeks and eventually a month apart are appropriate to monitor the progress of healing within the defect and to modify the obturator prosthesis to reflect those healing changes. As discussed in Chapter 6, the period of rapid change due to healing will vary from patient to patient, but changes in the defect will tend to become less dramatic and occur less frequently with time. When obturator modifications at monthly intervals become minimal, it is time to begin fabrication of the definitive obturator prosthesis.

The Definitive Obturator Prosthesis

It is not possible to describe in detail the design and fabrication of every conceivable variation of the maxillectomy obturator. There are, however, a number of basic principles that can be applied on a routine basis to the treatment process for the patient with teeth remaining in the maxillary arch following maxillectomy.

Definitive Obturator Mouth Preparation

During the healing period following maxillectomy, the patient is seen by the prosthodontist on a regular basis to adjust and modify the interim postsurgical obturator. In the later stages of this interim period, attention should be given to preparing the mouth for fabrication of the definitive obturator prosthesis. Teeth that were provi- sionalized should be definitively restored. Treatment of teeth on which endodontic therapy had been initiated should be completed. Definitive periodontal therapy may also take place during the late interim period. Every effort should be made to maintain the remaining maxillary teeth and to restore them to an optimum state of health in preparation for definitive obturator fabrication. As part of definitive dental care, prosthodontic planning for design of the obtura: tor prosthesis should take place. Determination of which teeth will be used as the primary abutment teeth is made taking into account the location of the teeth relative to the surgical defect and also the position of the teeth in the remaining arch, their coronal integrity, and their periodontal support. Strategic teeth that are determined to be in less than ideal condition may be strengthened by splinting them to adjacent teeth, or it may prove more prudent to modify the prosthesis design to circumvent weaker teeth altogether if if is felt that they will not add to the success of the obturator. Endodontically treated teeth that are to serve as abutments should be restored with cast restorations to maximize coronal strength and integrity. If intraradicular posts are deemed necessary, they should be of maximum allowable length, as the forces generated on the teeth by the obturator are expected to be extreme in some instances.

Dental care in preparation for definitive obturator fabrication should include a program of education for the patient. The importance of the remaining teeth and specific instruction in oral and defect hygiene should be emphasized for longterm health, comfort, and quality of life for the patient. Noncompliant patients or those unable to perform the necessary procedures may require the assistance of others to maintain oral hygiene, which should be addressed as part of definitive dental care.

Definitive Obturator Design Principles

Every prosthodontist has his or her own philosophy of removable partial denture design and it is not within the scope of this text to address philosophical differences. However, certain basic principles that apply specifically to the unique situation presented by an obturator prosthesis must be recognized and followed for maximum benefit in the function and comfort of the final prosthesis. Regardless of the size or location of the defect and regardless of the number and position of the remaining teeth, one basic principle is maximum distribution of support for the obturator. This is achieved by incorporating more of the remaining teeth into the design of the framework and maximizing the use of occlusal and cingulum rests and vertical guide planes to distribute the functional load. Maximum extension onto the residual palate, alveolar process, and any load-bearing areas within the defect will also increase the support for the prosthesis. Support may be obtained within the defect in the posterior lateral region by obturator contact with the pterygoid plate or surface of the temporal bone if the pterygoid plate has been removed. When present, residual alveolar process on the defect side may be extremely useful in resisting tissueward displacement of the obturator. Other structures, such as the remaining nasal septum, vomer, floor of the orbit, or other osseous structures present in the particular defect, should be considered potential support for the prosthesis. In general, structures that are covered with nasal respiratory epithelium are not amenable to load-bearing contact from an obturator. One may consider secondarily grafting skin onto such structures if they are deemed critical to improved support.

Retention for the obturator prosthesis should be based upon maximizing the retentive potential of the remaining dentition as well as retention from the defect itself. Retention of the obturator within the defect is discussed in Chapter 6; the resistance to rotational dislodgment other than along the path of insertion on the abutment teeth is discussed here. The design and position of retentive clasps or attachments should be planned carefully. As a general rule, clasp placement as close to the defect as possible is desirable. To create a more favorable fulcrum line for rotation away from the defect, traditionally called indirect retention, additional clasps should be placed on the teeth farthest from that first clasp placed adjacent to the defect. Usually this will result in clasp placement as close to and as far from the defect as possible, as advocated by Desjardins (1978). Clasps located at points between these two terminal clasps are likely to be nonfunctional and easily dispensed with. As an example, clasp position for the remaining arch illustrated in Fig 7- 1 would be most efficient if the central incisor were clasped with an additional clasp placed in the molar region. Clasps placed on the premolars would offer little additional retention. The design of clasps that disengage under occlusal loading is complicated if not impossible to achieve in the situation of the obturator because the load that may be most damaging to the abutment teeth occurs when the teeth are apart and indirect retention comes into play. Attempts to break the stress allowing rotational movement around the fulcrum when the teeth are apart are likely to cause unacceptable dropping of the obturator portion of the prosthesis. If the obturator is to stay in place, substantial stresses must be placed on the abutment teeth. To counteract this downward force, multiple occlusal rests and palatal guide planes on the teeth between the two terminal clasps will spread the dislodging force between as many teeth as possible. Occlusal contact from denture teeth on the defect side may also assist in maintaining the obturator in its fully seated position.

For the obturator prosthesis, retention must be defined as both resistance to displacement along the path of insertion and resistance to the rotational displacement of the obturator out of the defect due to the force of gravity and function of the surrounding tissues against the obturator. The latter is usually the more difficult to attain. In such situations the principle of indirect retention must be expanded to include the term *resistance form.* While resistance form is a term tradi-

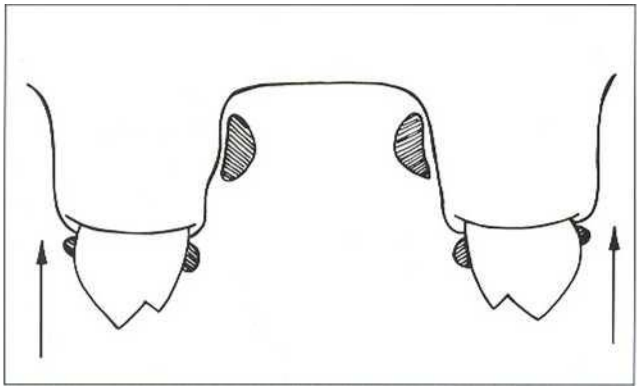


Fig 7-14 Schematic representation of a cross section of the palate with a partial denture framework in place. Note that the clasps located in opposing undercuts resist dislodgment along the path of insertion, and the clasps and bracing components resist dislodgment in all other directions. (Reprinted with permission from Taylor et al, 1988.)

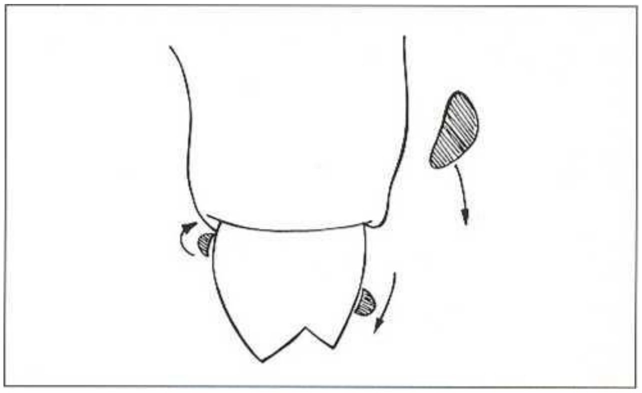


Fig 7-15 Representation of the same removable partial denture depicted in Fig 7-14 except that the opposite side of the arch has been removed as in a maxillectomy. The opposing clasps in retentive undercuts are no longer available and the remaining components will tend to rotate around the buccal clasp arm and fall away from the tooth. This tendency for rotational dislodgment occurs frequently with unilateral obturator prostheses. (Reprinted with permission from Taylor ef a I, 1988.)

tionally reserved for crown preparations, it is clearly appropriate to the unilateral removable partial denture design seen so frequently with obturator prostheses as well. If one assumes that the greatest potential dislodging force placed on an obturator is generated by gravity pulling downward on the cantilever of the obturator, the resulting rotational dislodgment must be resisted by the framework as it engages the abutment teeth as well as retentive characteristics that may be present within the defect itself. In the normal situation where teeth are present on both sides of the arch, the bracing effect of retainers in opposing undercuts resists dislodgment along any path, including the path of insertion (Fig 7-14). If one side of the assembly is lost, as is the case in a hemimaxillectomy, there is no longer resistance to dislodgment rotationally around the retentive clasp tip (Fig 7-15). Additional retentive clasps on the nondefect side will not be effective in resisting the tendency for rotational dislodgment. Even the use of lingual or palatal retentive components may not be effective, depending upon their relationship to the buccal arm and the radius of the dislodgment force between that buccal arm and the palatal surface of the abutment tooth (Fig 7-16). The only effective method available to counteract this rotational tendency is to create guide planes on the sides of the teeth facing the obturator, in this case the palatal surface (Fig 7-17). These guide planes limit the ability of the prosthesis to rotate around the fulcrum of the buccal arm. This increased resistance form becomes critically important when the surgical defect extends across the midline and when the remaining teeth are in a straight line and at great mechanical disadvantage (Figs 7-18 and 7-19). It is obvious that the longer the guide planes arc vertically the more effective they will tend to be. Traditionally, parallel guide planes have been incorporated into full-veneer cast crowns as seen in Fig 7-19b. More recently, guide plane contours have been successfully added to natural enamel surfaces using resin-bonded components (Taylor et al, 1988). A discussion of resin-bonded components can be found in Chapter 4. In situations such as those seen in Figs 7-18 and 7-19 it is equally important, to create accurately fitting guide plate surfaces into the framework of the obturator prosthesis. If space exists between the guide planes of the abutments and the plating surfaces of the prosthesis, the frictional resistance

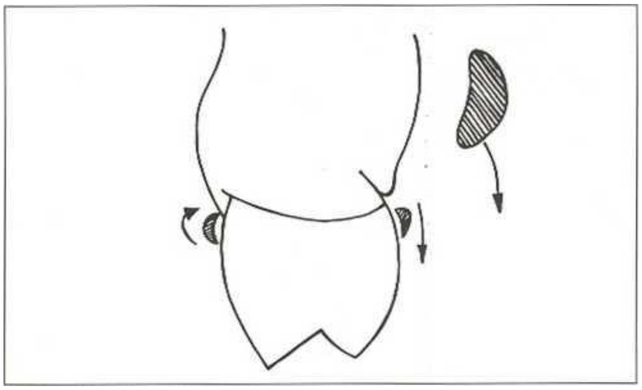


Fig 7-16 While palatally placed retentive components are frequently advocated for maxillectomy obturator prostheses, they may be ineffective in gaining resistance to rotational dislodgment depending upon the position of the clasp arms and the curvature of the tooth surface being engaged.

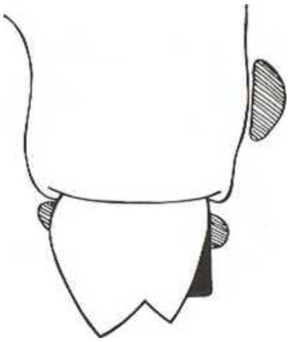


Fig 7-17 Effective resistance to rotational dislodgment can be gained by placing parallel guide planes on the surfaces of the abutment teeth directed toward the defect side. These guide planes, in effect, become indirect retainers that resist dislodgment of the obturator away from its tissue seat. The guide planes may be fabricated as part of cast crowns or may be relatively simple resin-bonded components. (Reprinted with permission from Taylor et al, 1988.)

to rotational dislodgment will not be effective. Intimate contact between the surface of the guide plane of the abutment and the guide plate surface of the framework must be maintained if rotational dislodgment is to be minimized. In this sense, the guide planes of the abutment teeth act as the indirect retainers for the prosthesis. The minimal distance from the fulcrum line of the clasp tips to these vertical indirect retainers puts them at a mechanical disadvantage. The more intimately the framework contacts the abutment teeth, the better the guide planes will function as indirect retainers. One method recommended to increase the effectiveness of guide plate frictional fit to rite abutment teeth is to avoid stripping or electropolishing the plating surfaces when the framework is being finished in the laboratory. By protecting the tooth-contacting surfaces from the polishing process, more intimate contact between the abutment guide planes and the framework can be attained (Tigs 7-20 and 7-21). Brudvik's (1999) text on advanced removable partial dentures provides a more detailed description of this technique.

Stability in a classic prosthodontic sense is resistance to dislodgment by functional forces (Desjardins, 1978). In the context of obturator prosthesis design and fabrication for the dentate patient, if the principles of support and retention (resistance) are fulfilled, the need for stability will automatically be satisfied. The maxillectomy or traumatic defect of the maxilla that results in loss of the anterior maxilla presents unique problems in stability' as well as retention for an obturator prosthesis (Tig 7-22). In this situation the function of mastication causes instability due to the upward and outward direction of mandibular closure. Mastication tends to force the obturator upward and, to some degree, outward with resultant rotation around the most anterior rests on the prosthesis. Resistance to this form of dislodging force is best counteracted by the placement of retentive clasps as far away from the defect as possible to resist rotation around the most anterior rests. At times when the teeth are apart, gravity' will tend to dislodge the obturator downward, which must be resisted by clasps situated as close to the defect as possible to resist rotation around a fulcrum through the two rests farthest away from the defect. The presence of two distinct fulcrum lines and the need to provide resistance to dislodgment around both will result in the need

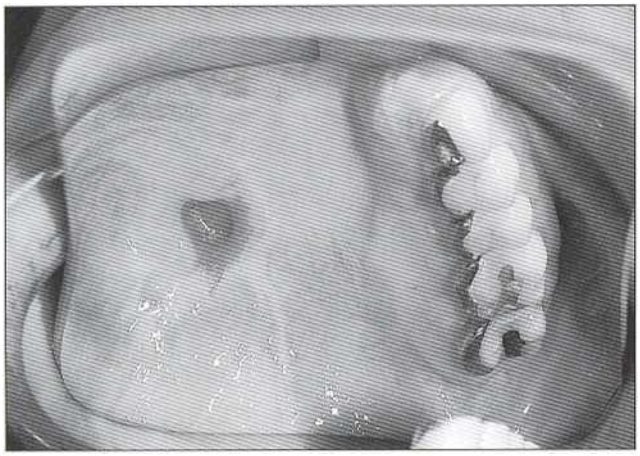


Fig 7-18a Maxillectomy in which the integrity of the palate has been preserved except for a small perforation. The remaining teeth are situated in a straight line and are not favorably positioned to support and retain an obturator prosthesis. The inability to engage retentive areas within the surgical defect makes retention even more difficult to obtain. Etched-metal, resin-bonded, parallel guide planes have been placed on the palatal surface of the remaining teeth to provide indirect retention to the obturator prosthesis that will be fabricated.

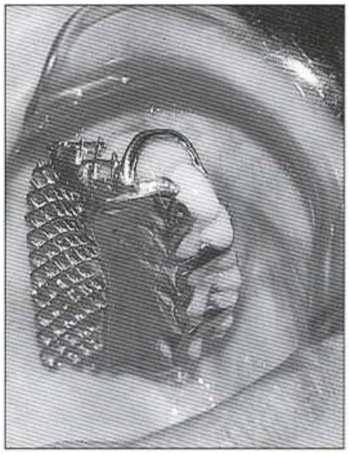


Fig 7-18b The cast framework for the obturator prosthesis shown at the try-in stage. The use of minimal clasping and maximal guide planes and occlusal rests provides an extremely stable framework. If retention of the prosthesis is to be hoped for, it will not be possible to provide stress release with any clasp design in this situation. If the obturator is to stay in position, the abutment teeth will need to absorb the load.

for rests and clasps located at the four corners of the remaining teeth, assuming teeth remain on both sides of the arch.

To summarize the design considerations of the framework for an obturator prosthesis, moderate retention located at the extreme points of the remaining teeth (as close to and as far from the defect as possible [Desjardins, 1978]), maximum support gained from occlusal and cingulum rests placed on all available abutment teeth, and maximum resistance form or indirect retention from parallel guide plane surfaces on as many abutment teeth as possible are recommended. These principles can be applied to virtually all situations requiring obturator design and fabrication.

Definitive Obturator Fabrication

When the design of the removable partial denture framework portion of the obturator prosthesis has been determined and the appropriate mouth preparation performed, the final impression for the nondefect portion of the prosthesis should proceed using whatever technique the clinician prefers for standard removable partial denture casting fabrication. The impression should be extended into the surgical defect sufficiently to allow the laboratory technician to extend the retentive meshwork portion of the casting into the region of the defect without interference from remaining anatomic structures (Fig 7-20). As a general principle, the nondefect portion of the obturator prosthesis, including restoration of abutment teeth, fabrication of the cast framework, and placement of any attachments to be used, should be completed before the impression of the defect area is undertaken. While some might question the value of this method of staging obturator fabrication, it is usually deemed important to finalize the adaptation and position of the retaining and supporting portion of the prosthesis (the cast framework) prior to extending into the surgical defect to create the obturator portion.

Based upon the above assumption, the cast framework is tried.in the mouth to verify complete seating and sufficient frictional fit to resist downward rotational dislodgment (Fig 7-21). When the framework has been adjusted to satisfy these prerequisites, autopolymerizing acrylic

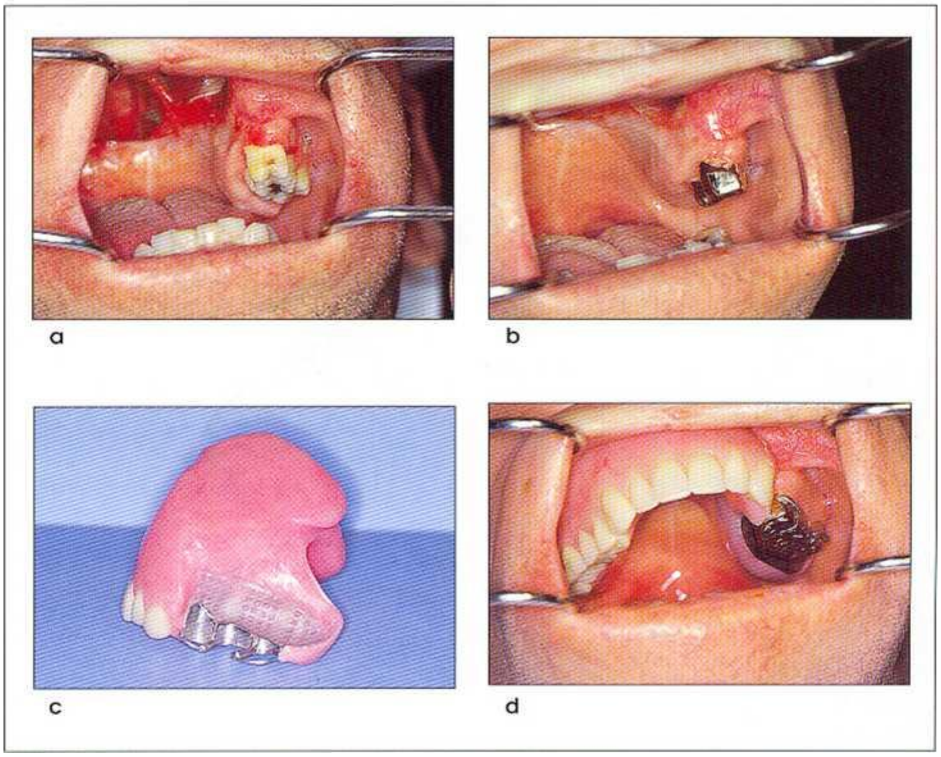


Fig 7-19a This patient has had a near total maxillectomy leaving only a small portion of alveolar process with three teeth. Cast full-veneer restorations were planned to provide parallel guide planes and to create a cuspless occlusal scheme in an attempt to reduce lateral occlusal forces on the three remaining teeth.

Fig 7-19b Cast restorations placed.

Fig 7-19c The final obturator prosthesis replacing the missing maxillary structures. Despite its size, the obturator is relatively light weight because it is hollow and the walls are of minimal thickness.

Fig 7-19d The obturator in position. It tends to remain in position due to the retentive aspects of the obturator as it relates to the surgical defect and the effect of the parallel guide planes on the three remaining teeth. Without a doubt, the obturator places substantial lateral forces on the three abutment teeth.

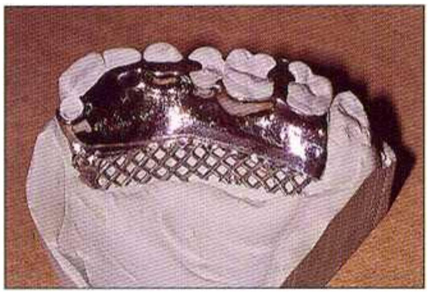


Fig 7-20 the cast framework as returned from the laboratory. The retentive mesh for acrylic resin attachment extends into the defect area approximately 1 cm. This is adequate for acrylic resin retention without interfering with the final shape of the obturator or its hollow walls. The attachment located adjacent to the central incisor will be affixed to the framework with resin at the time of framework try-in and will then be soldered to the framework for maximum strength.

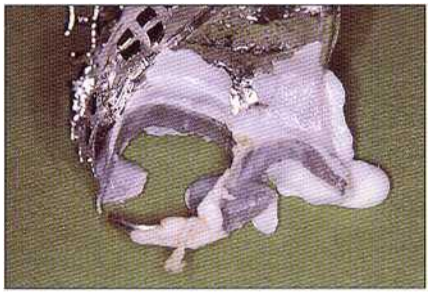


Fig 7-21 Silicone disclosing material has been applied to the framework and tried in. The intimacy of contact seen between the framework and the teeth will be sufficient to provide excellent bracing and stability for the final prosthesis. By protecting the as-cast surfaces of the framework in tooth-contacting areas, the frictional fit of the framework can be dramatically improved.

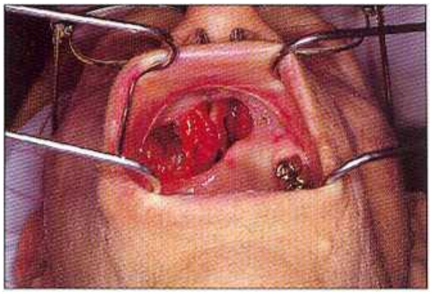


Fig 7-22 The resection of the anterior maxilla presents a difficult situation mechanically for obturator fabrication. The upward and outward direction of mandibular closure will tend to force the prosthesis in that direction rotating around the most anterior rests. The force of gravity will tend to dislodge the obturator in a downward direction rotating around a fulcrum through the most posterior rests. Clasps engaging undercuts at the four corners of the prosthesis are necessary to resist these two distinct dislodging tendencies.

resin is added to the retentive meshwork to serve as an impression tray for the obturator portion extending into the surgical defect. A wax occlusion rim may also be added to assist in evaluating facial support, tooth position, and occlusal registration (Figs 7-23a and 7-23b). The use of extended embrasure clasping is illustrated in this example of obturator fabrication as well. The advantage of this clasp design is to allow a single transocclusal connector that supports retentive arms engaging both a distobuccal retentive undercut on the second molar and a distobuccal undercut on the second premolar when no retentive area is available on the first molar (Fig 7-23c).

One of the most difficult aspects of generating the defect portion of an obturator prosthesis is to maintain the framework or nondefect portion in its original position relative to the residual palate and abutment teeth. The incremental addition of impression or reline material to the defect portion may frequently and unavoidably cause incomplete seating or rotation of the nondefect portion of the prosthesis away from its original position. Further additions only increase the lack of complete seating of the framework. One technique that will counter this tendency for inferior displacement of the prosthesis is to add an occlusal stop to the occlusion rim prior to the impression/extension of the surgical defect. The occlusal stop is added to the occlusion rim before the impression procedure of the defect begins, and with each addition of material to the obturator the patient is instructed to bring the teeth together into maximum intercuspation, thereby reseating the framework to its intended position (Fig 7-24). Not only does this ensure complete seating of the framework with each addition, it allows functional generation of the obturator impression in all positions, including when the teeth are together as in swallowing.

The impression of the surgical defect is carried out with the materials of choice until complete obturation is attained as described in Chapter 6. While satisfactory obturation of the defect is evaluated by speech production and absence of nasal leakage during swallowing, it is also important to once again ensure that the framework remains in its original relationship to the abutment teeth. When satisfactory obturation has been attained, the impression is removed and the original master cast is altered (Fig 7-25). If the obturator prosthesis is processed on the original cast without functional generation of the defect area, it can be performed as a reline/addition procedure as part of the delivery process.

Obturators for large defects should routinely be made hollow to reduce the weight. Numerous techniques have been described for the fabrication of hollow obturator bulbs and most have their merits. As a general principle, the shape and position of the defect may be the best determinant of whether the obturator is hollowed and sealed from the oral surface or from the superior surface (Fig 7-26). See Chapter 6 for further discussion of the hollow bulb obturator.

Delivery and Postinsertion Follow-up

The delivery appointment for a definitive obturator prosthesis is generally a relatively brief session because the patient has by this time become familiar with the interim obturator prosthesis and ideally will be prepared to transition into the definitive prosthesis. Postinsertion instructions should include recommendations for the frequency of removal and cleaning of the prosthesis and defect. Prior experience with the interim prosthesis will usually suggest how much difficulty the patient will experience with accumulation of secretions on the surface of the obturator as well as the need for oral hygiene counseling to maximize the ongoing health and stability of the abutment teeth. It should be assumed that the patient will wear the obturator 24 hours a day, and for that reason hygiene procedures must be re-emphasized at every visit to avoid complications of dental disease.

The patient should be seen approximately 24 hours following placement to assess the function of the obturator and to examine the defect area for early signs of irritation. Additional follow-up visits should be scheduled depending upon the findings at 24 hours, and adjustments should continue until it is determined that optimal adaptation of the obturator has been attained. Patient complaints of leakage from the nose or changes

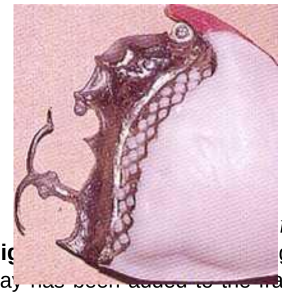


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Fig [illegible] g acrylic resin tray has been added to the framework seen in Fig 7-20. Note that the attachment adjacent to the central incisor is in place and will help maintain the framework in its correct position during the molding/impressing of the defect side.

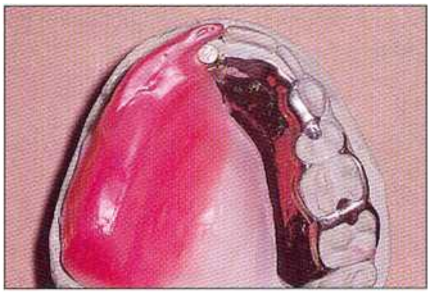


Fig 7-23b A wax occlusal rim has also been added to the tray prior to making the defect impression. This will help in supporting the facial tissues and will also support the interocclusal record if that is to be made at the impression appointment.

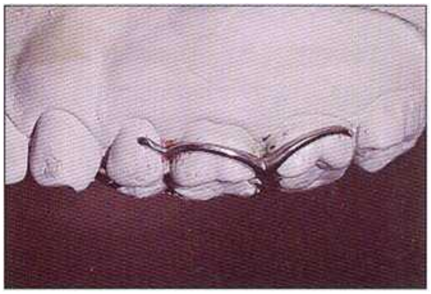
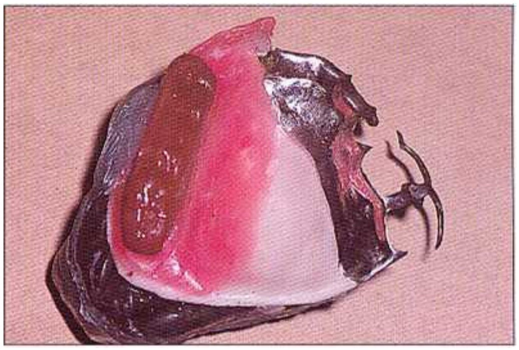
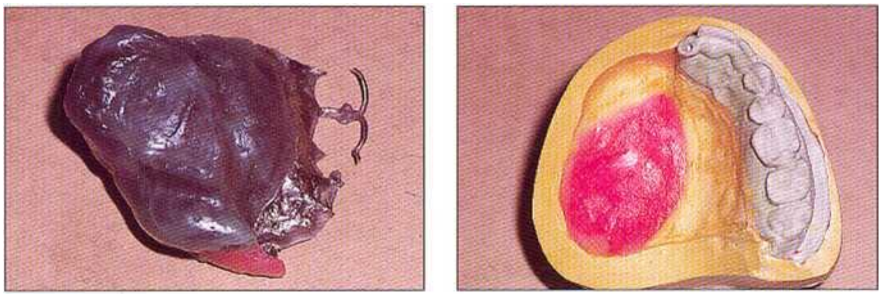


Fig 7-23c Absence of an adequate retentive undercut on the first molar necessitates the use of an extended embrasure clasp to gain retention from the distobuccal of the second premolar. This type of clasp reduces the need for multiple transocclusal minor connectors and provides effective retention for the prosthesis.

Fig 7-24 Prior to beginning the molding/impression procedure of the defect area, an occlusal stop was added to the wax occlusion rim of the tray/record base to assist in maintaining the framework in its original position during the impression procedure. This occlusal stop was fabricated of modeling compound and the framework was carefully maintained in its correct, fully seated position as the patient closed into the compound and while[1] it hardened. A more viscous occlusal registration material would have the tendency to rotate the prosthesis into the defect resulting in an obturator with premature occlusal contact on the defect side. A soft interocclusal material such as silicone would not displace the prosthesis as the patient closes the teeth together but would not give sufficient support against the downward displacement of the obturator during the molding process of the defect.





Figs 7-25a and 25b *(left)* The molding and final impression of the defect has been completed. Compound was used to extend the tray into the defect and to mold the periphery. The compound was then reduced approximately 2 mm and a mouth- temperature softening wax was applied and reinserted for 10 to 15 minutes to allow the wax to flow. After each addition to the bulb impression, the patient was instructed to perform movements of the mandible, to swallow, and to turn the head side to side. It is important that the patient be instructed to close the teeth into the interocclusal record (see Fig 7-24) during the molding procedures to keep the obturator from being displaced interiorly by the incremental additions of compound and/or wax. *(right)* The master cast has been altered following completion of the final impression.

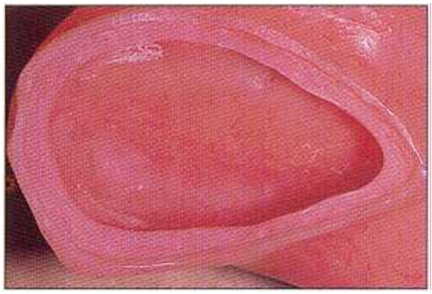


Fig 7-26 The superior surface of the obturator is prepared for the addition of a lid which may be made by adapting a sheet of wax directly to the finish line seen on the obturator, after which it is carefully removed and processed in resin.

in speech clarity will usually signal that the tissues contacting the obturator have undergone further change and readaptation is indicated. A discussion of the process of diagnostic obturator bulb modification is presented in Chapter 6.

Conclusion

Prosthodontic rehabilitation of the dentate maxillectomy patient is a lengthy and involved process. However, if attention is paid to the proper sequencing and details of treatment, it can be one of the most satisfying procedures in all of prosthodontics.

References

Aramanv M. Basic principles of obturator design for partially edentulous patients. Part I: Classification. J Prosthet Dent 1978;40:554.

A ram any .VI. Basic principles of obturator design for partially edentulous patients. Part II: Design principles. J Prosthet Dent 1978;40:656.

Brown K. Peripheral considerations in improving obturator retention. J Prosthet Dent 1968;20:176.

Brudvik J. Advanced Removable Partial Dentures. Chicago: Quintessence, 1999:71.

Desjardins R. Early rehabilitative management of the maxillectomy patient. J Prosthet Dent 1977;38:311.

Desjardins R. Obturator prosthesis design for acquired maxillary defects.] Prosthet Dent 1978;39:424.

Taylor T, Gerrow J, Brudvik J. Resin-bonded components for maxillofacial prosthesis construction: A clinical trial. J Prosthet Dent 1988;59:334.

Clinical Management of the Soft Palate Defect

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While the etiology of defects of the soft palate are extremely varied, ranging from cleft palate to oral malignancy and even to trauma, the methods used to treat patients so afflicted are, for the most part, quite similar and will be addressed here as a group.

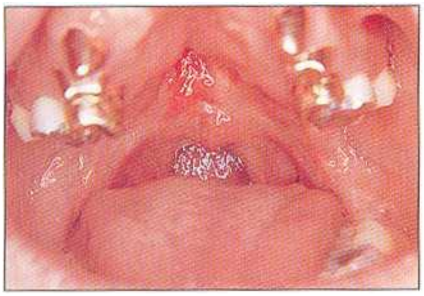
Defects of the soft palate frequently present as perplexing problems to the clinician. One of the difficulties is a lack of universal terminology. Without accepted terminology it is impossible to adopt a method of communication that allows universal understanding of specific clinical findings. Poor communication hampers discussions among the surgical and rehabilitative teams.

The term *velum* is often used interchangeably with the preferred *soft palate.* Such an interchange is incorrect, as the term *velum* refers to a covering or veil while the soft palate is actually a complex neuromuscular aponeurosis. Although the muscular activity of the soft palate provides function, it is also evident that a complex feedback system of afferent and efferent neural connections is required to control physiologic movement. Likewise, tissue bulk, in the form of connective tissue and epithelium, is required to provide contact with the pharyngeal walls during function.

Abnormalities of the soft palate can occur in different ways. The resultant defects can be grouped into three categories: congenital, acquired, or developmental. In the congenital cleft palate, the embryologic development of the hard and/or soft palate is interrupted. Surgical resection of neoplastic disease can alter continuity of the soft palate, resulting in an acquired defect. Diminished capacity of the soft palate to respond to functional demands may be developmental or the result of muscular or neurologic diseases.

Beyond etiology, defects are also classified according to the anatomy and physiology of the involved structures. These classifications identify the degree and type of palatopharyngeal closure. The diagnosis often determines the course of treatment. When some or all of the anatomic structure of the soft palate is absent, the term *palatopharyngeal insufficiency* applies. When the soft palate is of adequate dimensions but lacks movement because of disease or trauma affecting muscular and/or neurologic capacity, the term *palatopharyngeal incompetence* applies. The term *palatopharyngeal inadequacy* includes incompetence and/or insufficiency but may also suggest a reduction or absence of pharyngeal wall function.

Absence or loss of some or all of the soft palate results in insufficient structure or altered function of the remaining structure to provide closure with the pharynx (Fig 8-1). In this situation, an obturator prosthesis is designed to close the opening between the residual hard and/or soft palate and the pharynx. A pharyngeal obturator prosthesis, which may also be called a speech aid



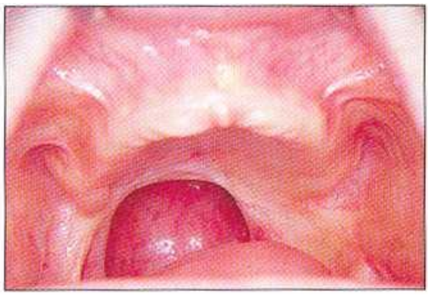


Fig 8-1 *(left)* Residual soft palate defect following surgical closure of cleft hard and soft palates.

Fig 8-2 *(right)* Surgical loss of the soft palate in an edentulous patient.

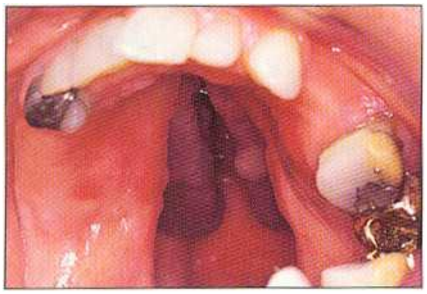


Fig 8-3a Unrepaired cleft of the hard and soft palates.

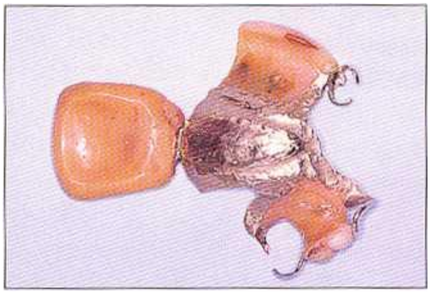


Fig 8-3b Hinged pharyngeal obturator.

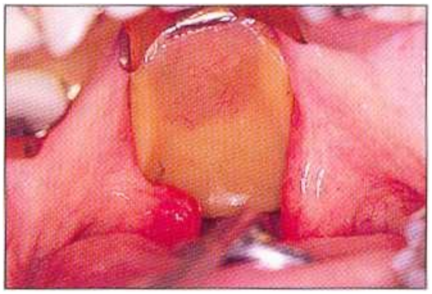


Fig 8-3c Hinged pharyngeal obturator in place. While this type of prosthesis can be effective, it does not offer a clear advantage over the fixed horizontal obturator and is rarely used today.

or speech bulb prosthesis, extends beyond the residual soft palate to create separation between the oropharynx and nasopharynx. It provides a fixed structure against which the pharyngeal muscles can function to effect palatopharyngeal closure. A meatus obturator is designed to close the posterior nasal choanac through a vertical extension from the distal aspect of the maxillary prosthesis. This obturator design may be indicated when the entire soft palate has been lost in an edentulous patient (Fig 8-2). Such a design will reduce leverage factors on the prosthesis but will not permit function of the pharyngeal muscles against it. The meatus obturator is often thought to be mechanical, whereas the fixed horizontal pharyngeal obturator is thought to be more physiologic. The hinged pharyngeal obturator is not often indicated today because of the mechanics involved in its fabrication and the apparent lack of advantage over the fixed horizontal obturator (Fig 8-3).

The soft palate normally establishes separation between the oral and nasal cavities. The soft palate moves in response to the physiologic demands of speech, deglutition, and respiration. The movement of the soft palate is a coordinated activity that results in varying degrees of closure between the soft palate and the pharyngeal walls during breathing, speaking, and swallowing. At some times there may be complete closure while at other times there may be varying degrees of opening. Palatopharyngeal inadequacy results in physical and psychosocial concerns for the patient. The objectives of prosthetic intervention are to prevent food and fluid leakage into the nose and to improve speech intelligibility. The prosthesis will include both pharyngeal and palatal or base sections. Pharyngeal extensions add bulk, weight, and leverage, thus generating stress to the supporting structures of the mouth through the palatal section of the prosthesis (Fig 8-4).

The greater the defect, the larger the obturator portion of the prosthesis will tend to be. Although larger prostheses create more weight, thereby negatively impacting prosthesis retention,

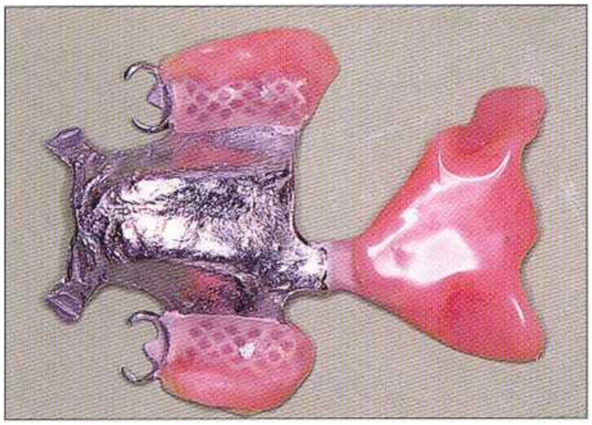


Fig 8-4a Pharyngeal obturator fabricated for a patient who had undergone resection of the left half of the soft palate. Note the large obturator required to provide the patient with optimal palatopharyngeal closure. Its weight puts a substantial load on the abutment teeth. The lack of posterior teeth available to retain the obturator may compromise success. The use of long, parallel guide planes on abutment teeth will aid retention and stability of the prosthesis.

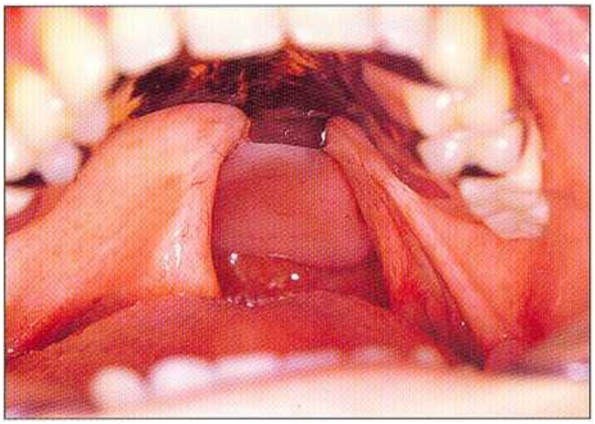


Fig 8-4b Obturator in place above and behind resected soft palate.

there are times when a smaller defect may be more problematic. Unilateral soft palate defects are more difficult to obturate because the function of the residual soft palate does not provide closure on the nondefect side, and it can be difficult to extend the obturator around or over the residual tissue. The configuration of the residual soft palate may complicate the prosthetic situation if the residual soft palate drapes toward the base of the tongue. House provided three classifications of soft palate anatomy (cited in Appleby and Ludwig, 1970). In his description of complete- denture therapy, the most favorable orientation of the soft palate occurs when this structure extends horizontally from the hard palate; the least favorable condition exists when the soft palate is nearly perpendicular to the plane of the hard palate. If is easier to lift and/or obturate incompetent or insufficient soft palates that are more horizontal.

The design of the prosthesis must apply the basic principles of support, retention, and stability to minimize the stress generated to the structures of the mouth (Table 8-1). Remaining natural teeth, residual ridges, endosseous implants, hard palate, and residual soft palate will all contribute, positively or negatively, to the support, retention, and stability of the prosthesis. All of these entities need to be considered in detail before prosthodontic intervention is undertaken. The location of the fulcrum line, retentive undercuts, and potential for indirect retention will be important factors in determining the prognosis.

If natural teeth or implants are present to provide retention and support for the prosthesis, the fulcrum litre for tissueward movement will pass between the most posterior occlusal rests on each side of the arch. Design for a pharyngeal obturator or palatal lift is not the same as designing a conventional Kennedy Class 1 or II removable partial denture. A conventional distal-extension partial denture under function rotates toward its distal-extension tissue base around a fulcrum line through the most distal occlusal rests. The pharyngeal obturator or palatal lift will tend to rotate away from the fully seated position under function and the fulcrum line will, in effect, shift to

Table 8-1 Principles of Support, Retention, and Stability of Prosthesis Design

Objective	Design feature	Result
Support	Occlusal rests	Rests on natural teeth limit movement toward tissue
	Major connector	Contact of major connector with tissue decreases movement
	Denture bases	Contact between denture base and underlying tissue
Retention	Retentive clasps	Undercuts on primary retainers engaged by clasps
	Skin graft	Junction of skin graft and host tissue creates retentive interface
	Residual ridges	Residual ridges and hard palate provide retention in edentulous patients
	Indirect retention	Occlusal rests on opposite side of fulcrum line interfere with rotation of the prosthesis away from tissue
	Endosseous implants	Direct retention of prosthesis
Stability	Major and minor connectors	Major and minor connectors prevent lateral motion of prosthesis and distribute stress
	Denture flanges	Contact of flanges with residual ridges diminishes motion

the anterior-most rests (the indirect retainers), with the more distally located clasps resisting the rotation. Retentive clasps placed into undercuts adjacent to the defect will resist the downward displacement of the prosthesis due to the effects of gravity and muscle activity. Long, parallel guide planes on the natural teeth will also assist in prevention of rotational dislodgment of the prosthesis (see Fig 8-4).

When natural teeth or implants are not present, retention of the prosthesis is problematic. Large, parallel residual ridges may be sufficient to retain the prosthesis, particularly if the superior aspect of the residual soft palate can be engaged. A square arch form may provide improved retention and indirect retention to the prosthesis. Regardless of the anatomic situation, every effort should be made to develop a border seal as in a conventional complete denture. In most situations, a denture adhesive will be necessary for use of the prosthesis because the obturator portion will tend to dislodge a denture that is not adequately retained (Table 8-1).

Types of Prostheses

The defect etiology may determine the type of prosthesis that is needed. Before treatment is initiated, the natural course of existing disease or the stage of rehabilitation should be considered. In many instances it will be unwise to proceed immediately to a definitive prosthesis. An interim prosthesis is indicated if the patient has remaining growth potential, if long-term disease prognosis is guarded, or if the natural progression of disease or rehabilitation demands frequent modifications of the prosthesis (Fig 8-5). In many situations it may be possible to use diagnostic interim prostheses to determine the ability to tolerate a definitive prosthesis. Sometimes the diagnostic prosthesis may take the place of definitive care, particularly when frequent modifications of the prosthesis are needed.

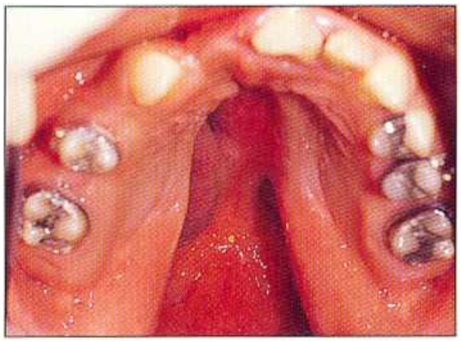


Fig 8-5a Adolescent patient, probably still growing, with large unrepaired palatal cleft is undergoing active orthodontic therapy.

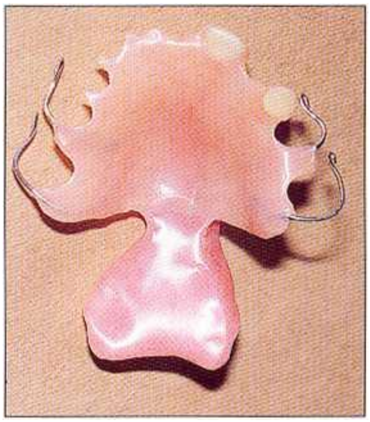


Fig 8-5b An acrylic resin interim obturator has been fabricated.

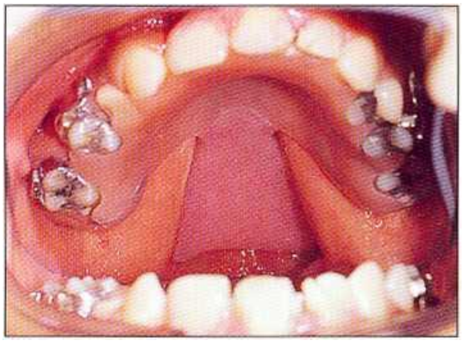


Fig 8-5c Obturator prosthesis in place. Frequent adjustments necessary to accommodate growth and orthodontic shifting of tooth position were easily done with the acrylic resin prosthesis.

Technical Considerations for the Pharyngeal Obturator Prosthesis

The pharyngeal obturator prosthesis does not displace the soft palate but replaces missing portions of the soft palate. Therefore, a pharyngeal obturator prosthesis has less active displacement force upon it than does a palatal lift. Despite the lack of active displacement forces, the obturator prosthesis continues to generate stress to the palatal portion of the prosthesis due to the forces of pharyngeal muscle activity and gravity. For this reason, the principles of retention and stability outlined in Chapter 9 for the palatal lift prosthesis should still be applied to pharyngeal obturator prosthesis construction as well (Fig 8-6).

The obturator section of the prosthesis is formed after the oral portion of the prosthesis is completed. In some situations it may be more convenient to develop the obturator portion once the framework of the oral section is completed but before full completion of the oral portion. A retentive loop is extended posteriorly from the palatal portion of the prosthesis to facilitate placement and retention of impression material in the pharynx. This extension should be parallel and as close to the palatal plane as possible (Fig 8-7).

High-fusing modeling compound is added to the retentive loop posteriorly into the defect area taking care not to impinge upon the soft tissues. This first addition will serve as the tray for subsequent additions and will resist sagging during repeated heating and insertion (Fig 8-8). Further additions of low-fusing compound are added until it contacts the posterior and lateral pharyngeal walls. Border molding is achieved by adding and removing modeling compound in the posterior and lateral pharyngeal areas. After the warmed modeling-compound addition is inserted, the patient is instructed to flex the neck fully to achieve contact of the chin to the chest. This movement will establish contact of the posterior aspect of the obturator with the soft tissue covering the anterior tubercle of the atlas. Lateral aspects of the obturator are formed by rotation and flexion of the neck to achieve chin contact with the right and left shoulder, respectively. The compound is then rewarmed and inserted and the patient is asked to swallow warm water to elicit pharyngeal muscle activity (Fig 8-9). When border molding is completed around the entire periphery, there should be no escape of liquid from the oral to the nasal cavities. Speech should sound normal, with the patient able to articulate plosive sounds such as *b* and *p* yet still be able to form the nasal consonants *m*, », and *n£*. If either

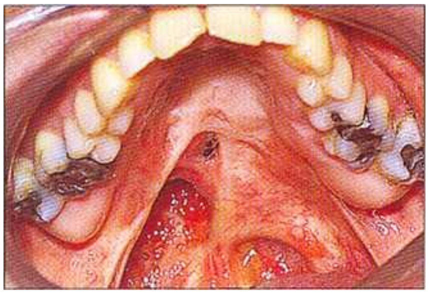


Fig 8-6a A young patient with an unsuccessful pharyngeal flap leaving a severely scarred oropharynx with several small openings into the nasopharynx.

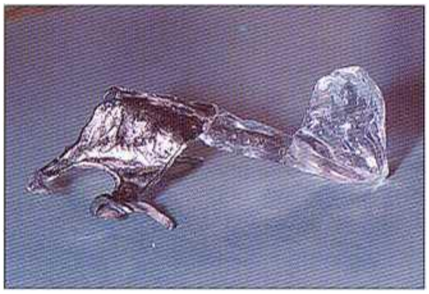


Fig 8-6b Pharyngeal obturator on a long extension from the oral base portion of the prosthesis.

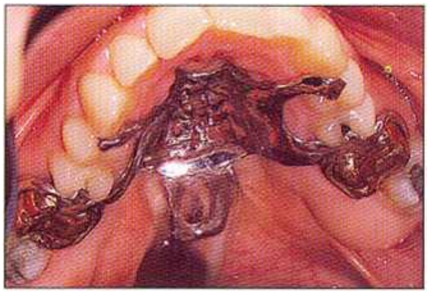


Fig 8-6c Obturator in place. Although the obturator is small and does not apply pressure to the pharyngeal tissues, the mere length of the cantilever of the obturator creates a substantial load on the abutment teeth. Note the location of the indirect retainers in relation to the clasps.

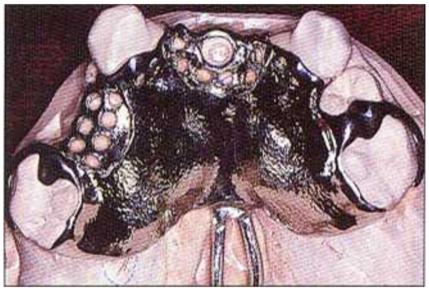


Fig 8-7 Maxillary removable partial denture framework with a posterior loop placed to retain the impression and final processed obturator portion.

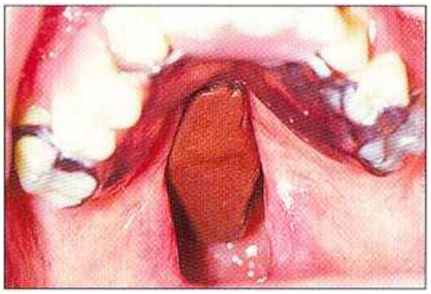


Fig 8-8 The initial addition of high-fusing compound extends into the defect without contacting the walls of the defect.

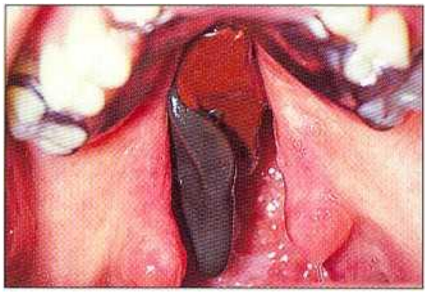


Fig 8-9 Low-fusing compound is added incrementally to border-mold the pharyngeal space. Note how the compound has been forced away from the residual soft palate by muscle activity during border molding.

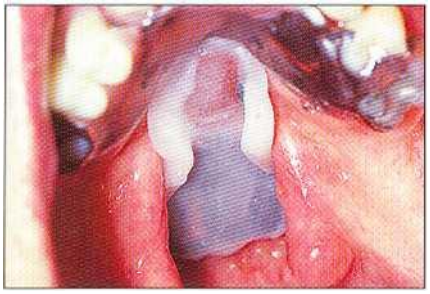


Fig 8-10a Mouth-temperature softening wax has been added to the scraped compound impression. The patient will wear the obturator for 8 to 10 minutes while performing border-molding movements including speech and swallowing.

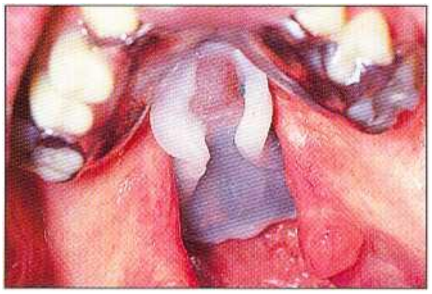


Fig 8-1 Ob The wax has been in position for 10 minutes. Note the space between the obturator and the residual soft palate walls generated by muscle activity during the molding session.

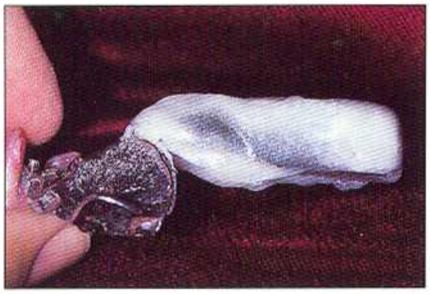


Fig 8-11 Final wax impression of the palatal defect.

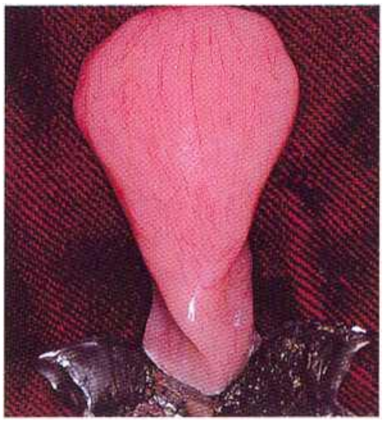


Fig 8-12 Superior portion of the completed obturator prosthesis. It is slightly convex in shape and highly polished.

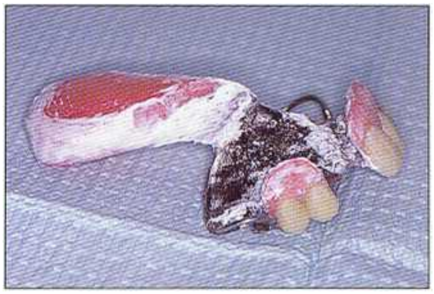


Fig 8-13 Pharyngeal obturator with pressure-indicating paste. Show-through on anterior portion is most likely due to drag from insertion and removal.

set of sounds is less than satisfactory, the borders should be checked for over- or underextension, depending upon the remaining speech deficit. The assistance of a speech pathologist or therapist is beneficial at this juncture to determine whether there is residual hypernasality or whether the patient's nasopharyngeal port is overly obturated making speech sound hyponasal.

After slight but even (1 to 1.5 mm) reduction of the compound on all peripheral surfaces of the obturator, a coating of mouth-temperature softening wax slightly thicker than the compound that had been removed is adapted to the modeling compound. The material is returned to the mouth and left in place for 8 to 10 minutes. The obturator may feel slightly tight to the patient, and sipping warm water will hasten the flow of the wax. Neck movements described above are repeated, as are additional swallowing and speech tests (Fig 8-10). Depending upon the degree of residual muscle function of the soft palate remnants and the pharyngeal walls, significant improvement in speech and reduction in nasal leakage may necessitate nearly complete occlusion of the nasopharyngeal port with the obturator. If the patient is dissatisfied with the inability to breathe comfortably through the nose, a compromise will be necessary between completely sealing the port and reducing the lateral aspects of the obturator until breathing is unstrained. Such a reduction of the prosthesis may result in a return of some degree of hypernasality. A nasal endoscope, if available, is of great assistance in determining areas needing further addition or reduction by viewing the function of the musculature against the obturator from above. The inferior portion of the obturator is maintained parallel to the horizontal hard palate whenever possible (Figs 8-11 and 8-13). This level will prevent the tongue from dislodging the prosthesis during deglutition.

Additions and subtractions are made to the wax and compound until there is no visual evidence of undue pressure being placed on oral tissues and the patient and clinician are satisfied that the best possible result has been attained. The obturator is carried to completion using conventional prosthodontic processing techniques. The inferior and superior surfaces of the obturator are highly polished while the tissue-contacting areas are only lightly pumiced and then buffed (Fig 8-12). At delivery, the obturator should be checked with a disclosing material to verify that no undue pressure is being placed on surrounding tissues (Fig 8-13).

Postinsertion instructions to the patient are similar to those given to any removable partial denture patient. Care and cleaning of the pros thesis, cleaning of the tissues covered by the prosthesis, and the amount of time the prosthesis should be worn each day should be discussed. Most patients are reluctant to sleep without their obturator in place to separate the nose and nasopharynx from the oral cavity, but the patient should be encouraged to remove the obturator for several hours each day, although this advice is probably largely ignored by most patients.

Dental Considerations for the Adult Cleft Palate Patient

Some attention must be given here to the oral and dental conditions frequently encountered with adult cleft lip and palate patients. Fortunately, the gross oral disfigurement so often resulting from early surgical attempts to repair labial and palatal clefts is becoming much less common. Advances in the management of the newborn and infant with cleft lip and palate have been very dramatic (see Chapter 5). Current state of the art for treatment of the newborn cleft patient notwithstanding, those patients with severe oral debilitation as adults do still need prosthodontic care. The most common defect seen in patients with a repaired cleft lip and palate is the missing or malformed maxillary incisor(s) in the region of the cleft. Conventional prosthodontic procedures for replacement of missing teeth are usually successful in this situation. Two concerns should be noted, however. First, the patient with a surgically repaired cleft lip will likely have a very high smile line, making the residual soft tissue defect in the cleft visible and less amenable to conventional fixed prosthodontic restoration because of the volume of missing soft tissue (Fig 8-14). The most esthetic restoration for such a defect may be a removable partial denture with a flange to mask the defect. The second concern is that when the cleft of the alveolus is not reconstructed with a bone graft, the two segments of the maxilla tend to move independent of each other. Placing conventional fixed prosthodontic restorations across the defect puts the integrity of the cement retaining the prosthesis at great risk of failure due to cement line failure, washout, and caries. Even double abutting the prosthesis on both sides of the cleft is no guarantee that cement failure will not occur. Alveolar bone grafting to close the bony cleft should be considered prior to fixed rehabilitation of the cleft palate patient regardless of the patient's age. It will greatly improve the long-term prognosis of the restoration.

Many adult cleft lip and palate patients have suffered from dental neglect as well as the effects of early surgeries to repair the lip and palate (Fig 8- 15). Surgical scarring, the lack of early orthodontic guidance, missing teeth, poor oral hygiene, and dental disease will all impact the adult cleft lip and palate patient. Many of these patients have also lost (or never attained) adequate vertical dimension of occlusion. Rehabilitation, or more accurately habilitation, of these patients involves careful diagnosis and treatment planning to attain an optimal outcome. Disease control of salvageable teeth and the extraction of hopeless or unacceptably malposed teeth are the initial steps of treatment. The fabrication of an interim diagnostic overlay removable partial denture at a substantially increased vertical dimension of occlusion may be surprisingly well tolerated. Final treatment for patients such as these may involve maxillary osteotomy to reposition the maxilla downward and forward, although this approach is quite likely to increase the potential of an insufficient soft palate that will then require surgical correction or an obturator prosthesis. Frequently the nonsurgical approach is decided upon, which many times involves the use of a maxillary overdenturc or partial overdenture that establishes correct vertical dimension, replaces missing teeth, provides an esthetic result with appropriate lip support, and may support a pharyngeal obturator (Fig 8-16). Such treatment can be extremely time consuming and difficult, but the outcome is usually worth the effort for all concerned (Fig 8-17).

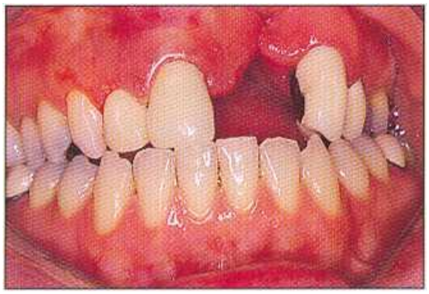


Fig 8-14 Central and lateral incisors missing in cleft area. Severe bony and soft tissue deficiency precludes conventional fixed partial denture as the treatment of choice.

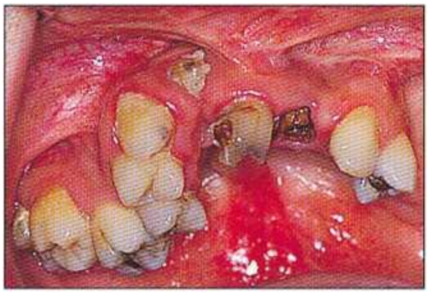


Fig 8-15 Surgically repaired cleft lip and palate in a 28-year-old male. Dental neglect and postsurgical scarring have made treatment for this patient extremely challenging.

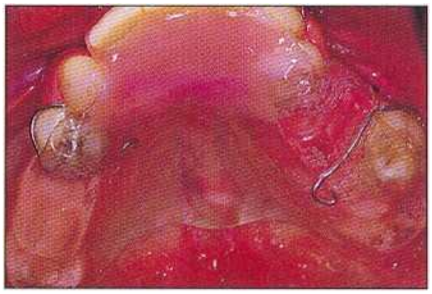


Fig 8-16 Provisional partial overdenture increased the vertical dimension of occlusion (VDO) 10 mm in the incisor area of this patient. The increase in vertical dimension changed the patient's maxillomandibular relationship from Class III to Class I. The patient was extremely comfortable with the increased VDO.

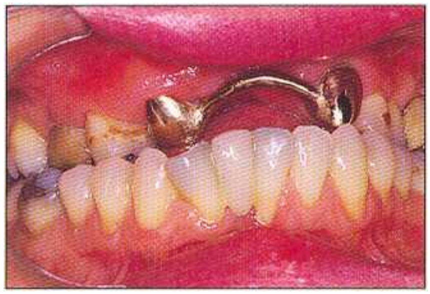


Fig 8-17a A 33-year-old female patient with teeth in normal occlusion. Gold tissue bar had been placed nearly 10 years earlier.

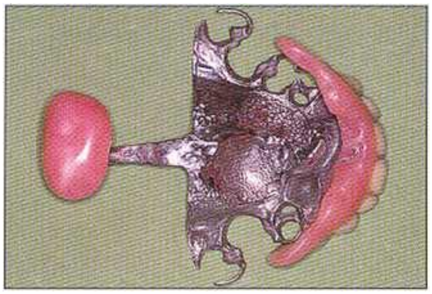


Fig 8-17b Partial overdenture with a pharyngeal obturator. Hidden clasps were used on the premolar abutment teeth to reduce metal display.

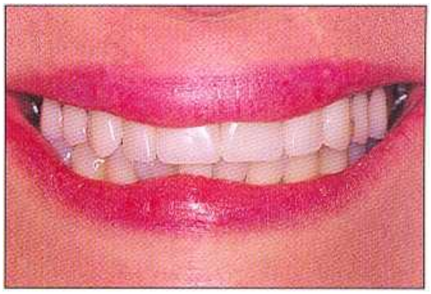


Fig 8-17c Partial overdenture in place.

Technical Considerations with the Meatus Obturator

The meatus obturator should be considered when the posterior extension of a fixed obturator prosthesis is likely to result in prosthesis displacement (Sharry, 1955). The meatus obturator projects vertically at the posterior aspect of the prosthesis to obturate the posterior nasal choanac (Fig 8-18). Because the vertical extension is, closer to the palatal portion of the prosthesis, there is less torque placed on the palatal portion, thus decreasing the tendency to dislodge. This prosthesis is most applicable to the fully edentulous patient who has undergone a total soft palate resection (Taylor and Desjardins, 1983). Since the posterior and lateral pharyngeal walls cannot function against a meatus obturator, speech with the obturator in place will tend to be hvponasal. With ideal obturation, nasal breathing will not be possible.

As with the other pharyngeal obturator prostheses, the oral portion or base of this prosthesis is fabricated to full extension in an effort to maximize retention, support, and stability. The vertical portion of the prosthesis is made in modeling compound supported by a wire loop extending vertically' into the area of the posterior narcs or choanae. The prosthesis is inserted with a rotational path, first seating the vertical extension to the posterior choanae and then seating the oral

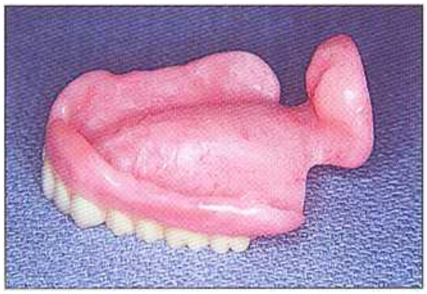


Fig 8-18 the meatus obturator extends vertically to contact the posterior choana of the nose.

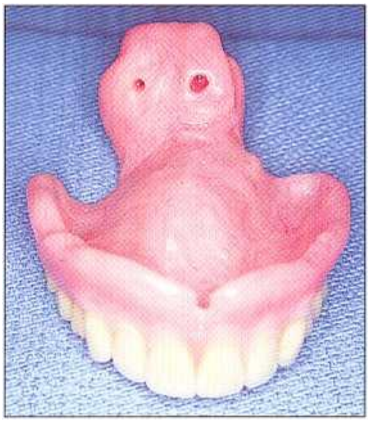


Fig 8-19 Small holes are added to the meatus obturator to permit moderate nasal breathing through the nose. Holes must be kept small or the benefit of the obturator will be lost.

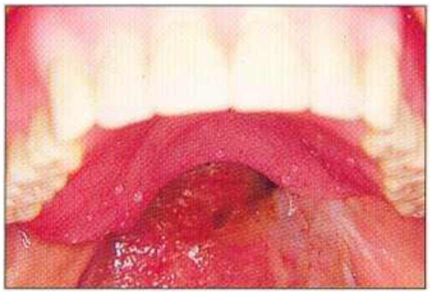


Fig 8-20 Meatus obturator in place.

portion of the prosthesis. Incremental additions are made to register the anatomy of the posterior nasal openings in low-fusing compound. When the anatomy of both posterior nasal openings has been registered in compound, the patient should not be able to breathe through the nose with the obturator in place. When the vertical extension has been formed satisfactorily in modeling compound, it is reduced 1 to 1.5 mm and mouth-temperature wax is added to refine the adaptation to the posterior choanae and to reduce the risk of applying too much pressure on the sensitive nasal mucosa. It should be noted that an exceptionally flared or undercut anterior maxilla will prevent the posterior-to-anterior rotational path of insertion required to successfully obturate the posterior choanae.

After the meatus extension has been processed onto the denture, it is necessary to determine whether the patient is satisfied with the subsequent hvponasal speech or whether it would be preferable to provide for nasal breathing at the expense of some increase in hypernasal speech. Most patients will prefer the ability to breathe through the nose. A small hole should be placed through each side of the prosthesis so that breathing is possible through both nostrils (Fig 8-19). Use the smallest opening possible at the best angle to prevent nasal regurgitation and slope the holes downward toward the pharynx to allow drainage posteriorly bv force of gravity (Fig 8-20).

Evaluation of Effectiveness of Treatment

Ideally', when treatment is complete the patient will have palatopharyngeal closure during speech and deglutition while unimpeded nasal breathing is still possible. Effectiveness of treatment with a palatal lilt or a pharyngeal obturator prosthesis may be evaluated through subjective or objective methods. Speech evaluation will determine the presence of nasality. Following treatment, the patient will experience hypernasal speech if the palatopharyngeal contact is ineffective. If palatopharyngeal contact is excessive, the patient will experience hyponasal speech. Trained listeners are often able to describe the quality of pharyngeal closure through speech alone (Millard, 1965; Marshall and Jones, 1971). The less experienced or less skilled observer may benefit from the input of a speech pathologist or therapist in assessing the patient. Patient reports of food or fluid regurgitation may indicate inadequate palatopharyngeal closure.

Objective methods for evaluation of palatopharyngeal closure involve direct visualization, indirect visualization, and measurement of air-pressure differentials. Direct visualization may be performed through the use of a nasal endoscope. This fiberoptic scope is used to determine the presence or absence of oropharyngeal closure (Conley et al, 1997; Pownell et al, 1997). Indirect methods of visualization involve the use of radiopaque fluids and cineradiography to assess fluid regurgitation (Warren and Hoffman, 1961; Blackficld et al, 1962; Mazaheri and Hoffman, 1962; Mazaheri et al, 1964). Air pressure in the oral and nasal cavities can be assessed to determine the presence of closure (Warren, 1979; Morr et al, 1989).

Objective methods of assessment require the use of testing armamentaria that may interfere with test results. In addition, the proper use of testing equipment demands time to establish skills, yet the improper use of equipment could prove dangerous to the patient (Pownell et al, 1997). Conversely, subjective testing may not have sufficient sensitivity to discern the borderline air or fluid emissions. Neither approach is perfect. Experience of the clinician may be the most appropriate method to determine the best test for the patient in question.

Summary

As with all phases of prosthodontics, there can be a considerable difference in soft palate defects from one patient to another. The goal of this chapter was to review the basic types of defects of the soft palate and to offer suggestions in their management with pharyngeal obturator prosthe- scs. There are many techniques that lend themselves to development of acceptable obturator prostheses. It is important that the clinician become familiar with a technique that she or he is comfortable with and can master. Application of that technique to the variety of soft palate defects should not be prohibitively difficult. It must always be remembered, and the patient must be so counseled in advance of treatment, that the prosthodontist cannot restore the intricate neuromuscular structure that is the soft palate. The clinician can only try to provide an alternative means for palatopharyngeal function. How successful that alternative is will depend upon the patient's ability to accept the defect and to adapt to an alternative environment.

References

Appleby R, Ludwig T. Patient evaluation for complete denture therapy. J Prosthet Dent 1970;24:11.

Blackfield LI, Miller K, Owsley J, Lawson L. Cinefluorographic evaluation of patients with velopharyngeal dysfunction in the absence of overt cleft palate. Plast ReconstrSurg 1962;30:44-1.

Conley S, Gosain A, Marks S, Larson D. Identification and assessment of velopharyngeal inadequacy. Am J Otolaryngol 1997; 13:38.

Marshall R, Jones R. Effects of a palatal lift prosthesis upon the speech intelligibility of a dysarthric patient. J Prosthet Dent 1971;25:327.

Mazaheri M, Hoffman E. Cineradiography in prosthetic speech appliance construction. J Prosthet Dent 1962; 12:571.

Mazaheri M, Millard R, Erickson D. Cineradiographic comparison of normal to noncleft subjects with velopharyngeal inadequacy. Cleft Palate J 1964;1:199.

Millard R. Changes in nasal resonance related to differences in location and dimension of speech bulbs. Cleft Palate J 1965;2:167.

Morr K, Warren D, Dalston R, Smith L. Screening of velopharyngeal inadequacy by differential pressure measurements. Cleft Palate J 1989;26:42.

Pownell P, Minoli), Rohrich R. Diagnostic nasal endoscopy. Plast ReconstrSurg 1997;99:451.

Sharry J. Meatus obturator in cleft palate prosthesis. Oral Surg Oral Med Oral Pathol 1955;7:852.

Taylor T, Desjardins R. Construction of the meatus-type obturator: Its advantages and disadvantages. J Prosthet Dent 1983;49:80.

Warren D. Perci: A method for rating palatal efficiency'. Cleft Palate J 1979; 16:279.

Warren D, Hoffman E. A cineradiographic study of velopharyngeal closure. Plast ReconstrSurg 1961;28:656.

Clinical Application of the Palatal Lift

o Kendra S. Schaefer, DMD o

Thomas D. Taylor, DDS, MSD

Gibbons and Bloomer described the first successful palatal lift prosthesis in 1958. Since that time there have been many publications about their fabrication, use, and effectiveness (Gonzalez and Aronson, 1970; Kipfmucller and Lang, 1972; Mazaheri and Mazaheri, 1976; LaVelle and Hardy, 1979; Yorkston et al, 1989; Warren et al, 1990; Turner and Williams, 1991). The term *palatal lift* prosthesis, however, is technically inaccurate because it is not a prosthesis but a positioning device.

Prosthodontists frequently provide palatal lift prosthcscs for patients with speech disorders due to palatopharyngeal incompetence. Comprehensive management for these patients requires close interaction between the prosthodontist and the speech-language therapist or pathologist. Utilizing videofluoroscopy, nasal endoscopy, and airflow pressure measurements, the prosthodontist and speech pathologist can make a complete assessment of palatopharyngeal function. These diagnostic techniques help determine the need for, design of, and postinsertion adjustments of the device.

The more frequently seen types of patients referred to the prosthodontist for evaluation for palatal lift fabrication are those with neurologic disorders affecting the oropharyngeal mechanism. While the anatomy remains normal for these patients, the musculature either no longer functions or functions at a reduced level of activity. Although these patients may present with similar symptoms of palatopharyngeal incompetence, the underlying problems can be very different. The etiology of palatopharyngeal incompetence may be due to a number of ncu- rodegencrative disorders, including multiple sclerosis, amyotrophic lateral sclerosis (ALS), tumors of the cranial region, or traumatic head injury. The presenting etiologies are so variable because the neurologic mechanism for palatopharyngeal function is so complex. The soft palate and pharynx are innervated by a nerve plexus (pharyngeal plexus) including fibers originating from the IX, X, and XI cranial nerves and possibly some fibers from the VII nerve. Any disease or disorder that affects the normal function of any of these cranial nerves or their central origins can have a significant effect on the function of the palatopharyngeal complex. As with any prostho- dontic procedure, before attempting to fabricate a palatal lift the proper diagnosis, in this case loss of motor function of the soft palate, must be made.

As noted in Chapter 8, *velopharyngeal* and *palatopharyngeal* are largely interchangeable terms, the latter being the preferred term. Palatopharyngeal (or velopharyngeal) incompetence, defined as having normal anatomy but ineffective or absent motor function, is distinguished from palatopharyngeal insufficiency. Palatopharyngeal insufficiency is caused by abnormal anatomy. Typically, patients with cleft palate or

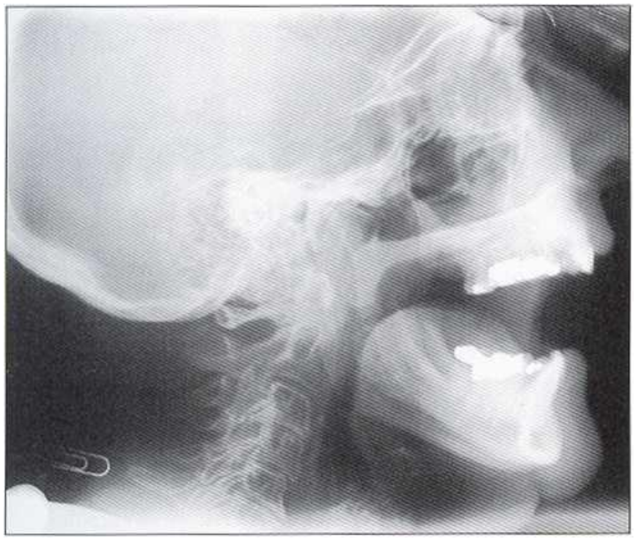


Fig 9-1 Lateral cephalometric radiograph of a 77-year-old female diagnosed with hypernasal speech. Her speech intelligibility tended to deteriorate the longer she spoke. This radiograph demonstrates that she is able to elevate the soft palate to contact the posterior pharyngeal on a sustained "ahhh" effort. Palatal lift fabrication will likely be beneficial for this patient due to the residual muscle activity.

those who have suffered resection of the soft palate or lateral pharyngeal wall suffer from palatopharyngeal insufficiency. As a general rule, palatopharyngeal insufficiency is treated with a pharyngeal prosthesis or speech bulb prosthesis. Palatopharyngeal incompetence is treated with a palatal lift.

Several authors have suggested that the use of a palatal lift could stimulate the soft palate into improved function and at times the use of the lift could be discontinued (Beery et al, 1983, 1985; Wolfaardt et al, 1993). Others, however, dispute the claim (Witt et al, 1995). When one considers the myriad causes of palatopharyngeal incompetence, it is unlikely that generalizations regarding the effectiveness of the palatal lift can be made. The use of a palatal lift in a patient suffering from a progressive neurologic disorder such as ALS is not likely to benefit from the effects of palatal stimulation. By contrast, a patient who has suffered a stroke or closed-head traumatic injury may indeed demonstrate improved soft palate function with time, although the stimulating effect of a palatal lift might still be questioned. The young patient with a repaired cleft of the palate who is also a potential candidate for a pharyngeal flap procedure might first benefit from the use of a palatal lift to stimulate greater palatopharyngeal muscle activity and possibly avoid the need for surgery.

Palatopharyngeal Function

The muscles of the soft palate and pharyngeal walls work in concert to effect palatopharyngeal closure. The levator veli palatini and the superior constrictor are the primary muscles performing the majority of the work of closure. When the levators palatini (paired muscles joined in aponeurosis at the midline of the soft palate) contract, the soft palate moves superiorly and posteriorly until it contacts the posterior pharyngeal wall. This contact occurs at or slightly above the level of the palatal plane. The level of posterior wall contact also corresponds with the level of the anterior tubercle of the atlas, a convenient radiographic landmark (Fig 9-1). The posterior pharyngeal wall may occasionally move anteriorly to contact the elevated soft palate, although this is usually only seen in patients with cleft palate who have developed compensatory movement of the posterior aponeurosis of the paired superior constrictors across the midline of the posterior pharyngeal wall. This posterior pharyngeal wall function is referred to as the Passavant pad or ridge. While of interest, the Passavant pad is rarely of clinical significance. This small ridge of muscle contraction tends to lag slightly behind the rest of the sphinctcric closure mechanism and fatigues rapidly on repeated contraction (Dr John Palmer, professor emeritus, Department of Speech

Pathology, University of Washington, Seattle, personal communication, 1985).

Simultaneous with soft palate elevation, the paired superior constrictors in the lateral pharyngeal walls move medially to contact and press into the lateral portion of the elevated soft palate. While Skolnick et al (1973) described four patterns of normal velopharyngeal closure, all of which have a sphincteric pattern of muscle activity, without nasal endoscopy the clinician cannot determine which of these patterns a patient may present. Fortunately, the specific pattern of sphincteric closure is of little consequence to palatal lift construction. As a general principle, normal speech requires full closure of the nasopharyngeal sphincter, with the exception of the nasal consonants m, n, and ng. Air escape through the nose during the production of any speech sounds other than these will give the listener the impression of hypernasality. Tight palatopharyngeal closure is also necessary for normal swallowing.

Palatopharyngeal incompetence is characterized by hypernasality and a decrease in intraoral air pressure during the production of oral speech sounds, causing decreased intelligibility. Patients who may benefit from fabrication of a palatal lift are those who exhibit palatopharyngeal incompetence.

Indications and Prosthodontic Determinants for Lift Fabrication

The obvious indication for fabrication of a palatal lift is the diagnosis of palatopharyngeal incompetence. Palatopharyngeal incompetence is not all or nothing. Varying degrees of incompetence range from barely noticeable to extreme hypernasality'. Variation can frequently be observed in the same patient and can be caused by fatigue or changes in posture. A patient may begin to speak normally, but by the end of several sentences hypernasality may become more noticeable. The speech therapist or pathologist should have the responsibility to determine whether palatopharyngeal incompetence is a clinical problem for the patient and the extent to which hypernasalitv affects speech intelligibility. It is the prosthodontist’s responsibility to determine whether the fabrication of a palatal lift is possible and, if so, how to proceed in its construction.

The patient referred for palatal lift construction should be examined with the speech professional present whenever possible. It is important to understand firsthand what the intended objectives of the speech professional are and to explain the prosthodontic considerations relating to the prognosis of the procedure. While the palatal lift is a fairly common service provided by some prosthodontic practices, few speech therapists and pathologists are completely familiar with the use of a palatal lift and may not understand the limitations of the service. It is not uncommon to receive a referral from a speech professional who has not previously worked with a patient with a palatal lift. In such situations it is as important to educate the speech professional as it is to treat and educate the patient needing the lift. The palatal lift is not a panacea for hypernasal speech; it is but one tool that may be successful in varying degrees depending upon many factors. Many times hypernasality is only one of several problems a patient is experiencing with speech. Determination by the speech professional of what other articulation deficits are present will assist in formulating a realistic prognosis for the lift.

A primary requirement for a successful palatal lift is retention. Because the palatal lift is a posterior extension cantilevered from a removable denture base, the ability to keep the base portion in the correct position is critical to success of the lift. Teeth (or implants) that can serve as abutments for the lift are requisite, although occasionally a lift can be successful with a complete denture as the base (Fig 9-2). Abutment teeth should be strategically located to give the maximum mechanical advantage to the lift. Posterior teeth, preferably second or even third molars, arc the best abutments for palatal lift construction because they are closest to the cantilevered lift extension. The absence of posterior teeth, while not a strict contraindication to lift construction, will likely decrease the prosthodontist’s ability to fabricate a retentive palatal lift that will resist dislodgment. Retentive undercuts on the abutment

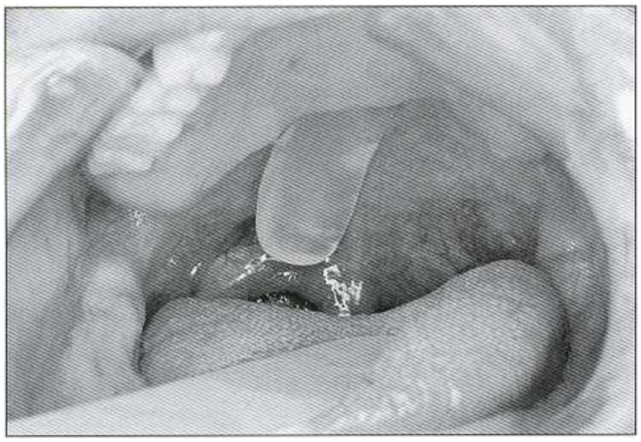


Fig 9-2 Palatal lift extended onto the right soft palate from a maxillary complete denture. The patient suffered from paralysis of the right palatopharyngeal muscle complex due to a cardiovascular accident. The lift was successful due to excellent denture retention anatomy, a well-fitting denture, and the use of denture adhesive.

teeth are necessary and can be created with the addition of composite resin or orthodontic brackets if natural tooth contours arc insufficient.

The prosthodontist must determine the potential amount of force that will be required to lift the soft palate to create the desired effect prior to committing to lift fabrication. Usually, patients with little or no soft palate movement will present with a flaccid paralysis of the soft palate muscles. The soft palate is easily displaced upward by pressing on it with a mouth mirror or tongue blade. This test should be performed at the initial consultation. If the soft palate resists displacement because of fibrosis or tonicity of the muscles, a palatal lift may not be successful. Too much force will be required to lift the palate and will likely result in a lift that cannot be kept in place or in pressure irritation and ulceration of the mucosa of the soft palate. The mouth mirror test is a quick indicator of the potential for success of the lift. It should be noted here that contact with the soft palate does not, by itself, elicit a gag reflex. The gag reflex is initiated by contact with the dorsum of the posterior tongue and/or the tonsilar pillars. The clinician should be careful not to touch the tongue with the mirror during this test to determine soft palate displaccability.

Another diagnostic consideration that will have bearing on the success of palatal lift fabrication is the amount of residual pharyngeal wall function. A palatal lift functions best when there is residual function of the superior constrictor muscles and is especially effective if the levator muscles still have some ability to contract. The ideal palatal lift is one that assists the pharyngeal musculature to complete normal closure. By positioning the weakened soft palate closer to the posterior pharyngeal wall, residual muscle activity may be sufficient to complete closure. This situation then allows the patient to maintain a nasal airway and yet complete pharyngeal closure for speech and swallowing. If examination reveals a complete lack of soft palate or lateral pharyngeal wall movement when the patient is asked to say “ahhhh” with the mouth wide open, a palatal lift will need to occlude completely the nasopharyngeal port for hypernasality to be eliminated. This will, in turn, create another set of problems, including inability to breathe through the nose and hyponasal speech. Wearing a palatal lift that completely eliminates nasal breathing may also reduce the patient’s willingness to wear the device.

A final determination that must be made prior to palatal lift construction is the patient’s ability to manipulate the lift intraorally. Frequently, patients with neurologic deficits that create the need for palatal lift assistance also have compromised manual dexterity' and may not be able to insert and remove the lift. If the patient is not capable of insertion and removal of the lift, another person—family member, nurse, or aide— must be completely familiar with the insertion, removal, and care of the palatal lift.

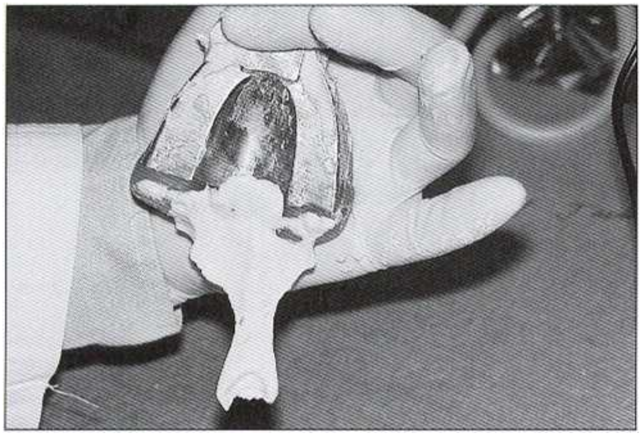


Fig 9-3 A reversible hydrocolloid impression made for a patient with neurologic deficit of the hypopharynx. Fortunately, the material ceased flowing just as it reached the epiglottis, the impression of which can be seen at the bottom of the impression. Risk of aspiration of impression material is elevated in patients with such neurologic deficits.

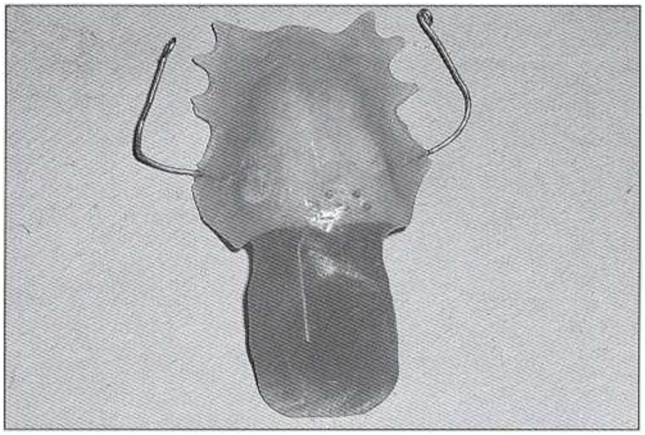


Fig 9-4 Palatal lift fabricated with retentive clasps that extend beyond the retentive area on the first molar in the form of loops that can easily be grasped by the patient for lift removal.

Fabrication

While some clinicians recommend fabricating the lift portion of the palatal lift over several visits, we have found it more convenient and completely acceptable to generate the lift portion of the device during one clinical session.

It is strongly recommended to fabricate the palatal lift as a provisional device with an acrylic- resin base portion to determine the success of treatment before committing to a cast removable partial denture framework. This is particularly advisable for a young patient whose growth is not complete or for a patient whose needs are expected to change frequently. If a east metal framework is preferred, fabrication of the oral portion of the lift is identical to the fabrication of a removable partial denture framework, including design and mouth preparation.

With either method of base fabrication, the initial visit includes the making of accurate reversible hydrocolloid impressions of both arches. Caution must be exercised when making impressions for a patient with neurologic deficit because normal protective reflexes may be lacking and airway obstruction is a real risk (Fig 9-3). While caution must be exercised, an attempt should be made to capture as much of the posterior palate as possible. Kxtcnsion of at least 2 cm posterior to the fovea palatini is desirable. The tray in this area must support the impression material so that the soft palate is displaced by the impression. This will allow placement of the wire loop in the proper position to support the lift portion of the device. For a patient with an exceptionally long arch form, a custom tray may be required to facilitate registration of the soft palate.

Surveying the resultant cast will determine the presence or absence of adequate retentive areas on the abutment teeth. The ideal position for the retentive clasps to engage is in a distobuccal undercut on the most posterior tooth on either side of the arch. This will place the retentive elements as close to the cantilever of the lift portion as possible. If the patient has limited manual dexterity, it may be necessary to provide retentive clasps directed anteriorly with extended loops that permit easier release of the clasps for removal of the lift by the patient (Fig 9-4).

Retention of the lift will largely dictate success or failure of the palatal lift and cannot be overdone from the standpoint of lift support. Clasps retain the framework of a partial denture on the teeth but, in the case of a palatal lift, they also

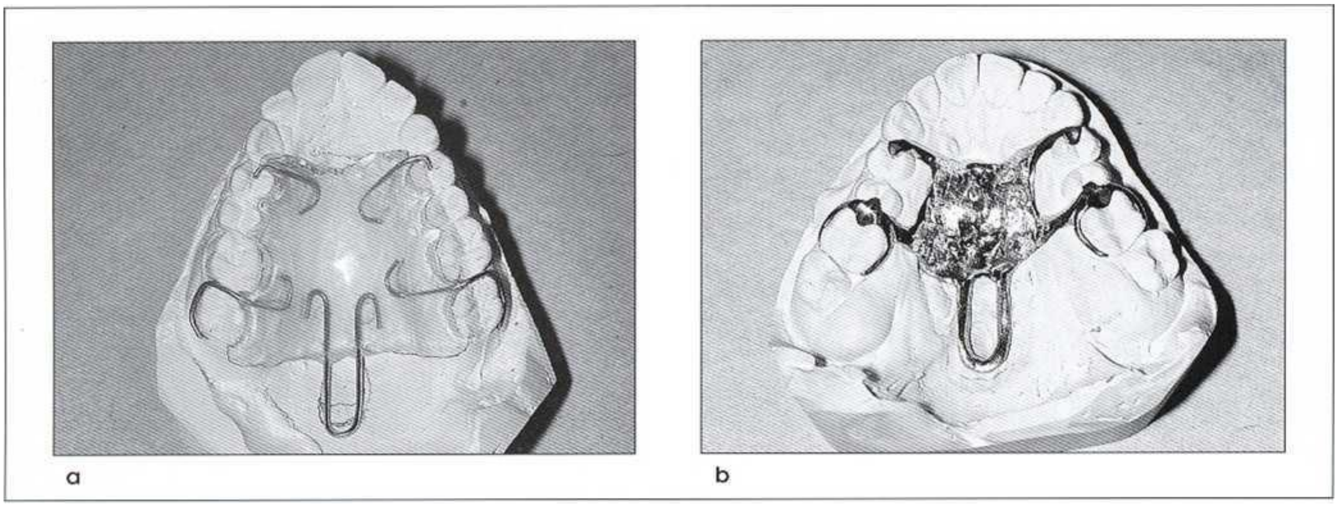


Fig 9-5a Acrylic-resin base portion for a palatal lift. Note that the retentive clasps are anteriorly based and engage retentive undercuts as close as possible to the cantilever of the lift portion. Also note the wire occlusal rests on the first premolars that serve as indirect retainers.

Fig 9-5b Cast metal framework for a palatal lift prosthesis in a patient with a repaired palatal cleft. Basic design principles remain the same.

support the lift portion in its functional position. If wrought wire clasps are to be used, they should engage approximately 0.04 to 0.05 inch of undercut. This is particularly true when clasping molar abutments because the length of the clasps will tend to make them more flexible. If orthodontic brackets are to be used for retention, the clasps must approach from the distal and continue anteriorly at least two additional teeth to allow the patient to grasp the clasp and reflect it laterally to disengage the lift (Fig 9-4). An 18 gauge or heavier wire should be used; wire of less diameter will fill out of adjustment more frequently and will not be sufficiently retentive. If sufficient retentive undercut is not available on the most posterior teeth, additional retention may be gained by placing composite resin in the area of the tooth where increased retention is desired.

Regardless of whether an acrylic resin or metal base is chosen, the design principles should be similar. The retentive clasps should engage undercuts as close to the posterior cantilever as possible. Additional clasps on teeth more anterior to these are unlikely to provide additional resistance to dislodgment by the downward push of the lift portion. While only one very retentive clasp is necessary on each side of the arch, it is equally important to utilize indirect retention as far anteriorly as possible to make the retentive clasps effective (Figs 9-5a and 9-5b). The mesial marginal ridge/fossa of the first premolar is usually a good position for the indirect retainer as it is far enough anterior to the fulcrum line to provide favorable leverage.

If the treatment plan is to fabricate an interim acrylic-resin palatal lift and if no additional mouth preparation is necessary prior to fabrication, the base portion of the lift may be fabricated on the initial cast obtained at the first appointment, and the second appointment then becomes the lift-generation appointment. More frequently, tooth modifications such as rest seat preparations and the placement of composite resin for additional retention arc required, and the second appointment is used for mouth preparation and making the final impression. It is extremely important that the speech pathologist or therapist be present during the lift-generation session. It has been our experience that if the speech professional is not present at this session, additional sessions will be required to demonstrate that maximum benefit of the lift has been attained. It is helpful if the speech professional comes to the session equipped with diagnostic tools to evaluate hvpernasality and nasal resonance. Nasal endoscopy is the method of choice to evaluate the effect of palatal lift therapy, but other tests are also effective in varying degrees. Experience has shown that it is worthwhile to invest in a nasal endoscope and to become familiar with its use. The endoscope is extremely valuable in the fabrication of palatal lifts and obturator prostheses. The endoscope reduces the guesswork in evaluating effective obturator seal and in locating the source of leakage when it occurs.

The retentive loop for the lift portion of the device should extend posteriorly from the base portion approximately 2 cm. This length will provide adequate support for the lift-molding process but will not extend so far as to interfere with processing. The loop should be on the same plane as the hard palate but should have slight relief between itself and the cast to allow for impression material and ultimately acrylic resin to coat the superior surface (Fig 9-6). The width of the lift in the area immediately posterior to the oral portion (the isthmus) does not need to be excessively wide, as this portion does not function but is rather a connection between the base portion and the lift. It should, however, be sufficiently wide and thick to support the lift under heavy pressure without fracturing.

At the lift-generation appointment the oral portion with the loop attached is tried in and adjusted as necessary to ensure complete seating. The loop should be in contact with and slightly displacing the soft palate. Generating the lift portion is different from generating a pharyngeal obturator prosthesis in that border molding to register the functional movements of the surrounding musculature is not done. Modeling compound is applied to the loop, shaped, flamed to create a smooth surface, and then chilled before placing it into the mouth. If softened compound is placed in the mouth, the soft palate will displace it downward and the lift action will not occur. Displacement of the soft palate is the goal of the procedure and can only be accomplished with hardened compound.

The first addition of compound should cover the loop evenly and extend several millimeters beyond (Fig 9-7). The chilled compound is carried to the mouth and seated. The patient is allowed to wear the palatal lift for several minutes at this stage to begin to become familiar with the sensation of the lift. Small additions arc made to the compound posteriorly until the soft palate is brought into light contact with the posterior pharyngeal wall. At this stage, space will remain between the soft palate and lateral pharyngeal walls. Reduction of hvpernasality is not likely until the lateral extent of the lift is increased sufficiently to reduce the size of the lateral ports. Following each addition, the patient is asked to breathe through the nose and attempt speech. It is important to avoid adding excess compound to the lift on its oral surface. If the posterior tongue contacts the underside of the lift, the patient will experience severe gagging. While the speech drills the patient is taken through are at the discretion of the speech professional, those sounds that require the creation of intraoral air pressure are very effective in determining the reduction in hypernasality: *b* and *p* are plosive sounds requiring intraoral pressure. Asking the patient to articulate *baby* or *paper* will quickly reveal whether the palatopharyngeal sphincter is closing tightly enough to build oral pressure (Fig 9-8).

Enlargement of the lift ceases when the speech professional is satisfied with the result, when the patient can no longer breathe through the nose, or when the downward force of the soft palate dislodges the lift and the retentive limit of the clasps has been passed. If the patient can no longer breathe through the nose, compound is removed from the lateral aspects of the lift until breathing is restored. In the ideal situation, lateral pharyngeal wall movement will allow the maintenance of lateral breathing ports that close down when the patient speaks. Frequently, however, the elimination of hypernasal speech will require the complete elimination of the nasal airway.

It is at this point in the session that nasal endoscopy is extremely valuable. The endoscope can determine not only the amount of lateral wall function but its location as well. By making additions or subtractions to the lift in the areas determined by endoscopy, maximum efficiency and minimal overdisplacement of the soft palate can occur. If an endoscope is not available and if

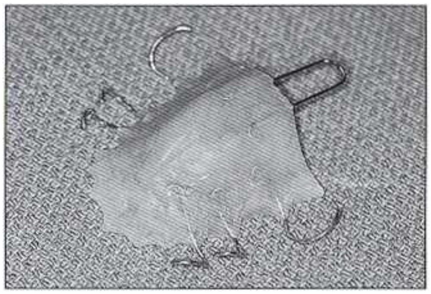


Fig 9-6 Oral portion of an interim palatal lift. With this design, the anterior embrasure clasps serve the purpose of indirect retainer but are not likely to aid in retaining the lift. The posterior wire loop extends approximately 2 cm toward the posterior on the plane of the palate.

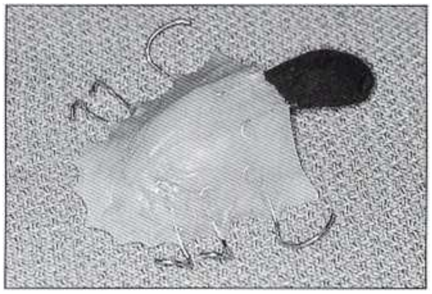


Fig 9-7 Initial addition of compound to the loop should be minimal. The patient is allowed to wear the palatal lift for several minutes to become more comfortable with its presence.

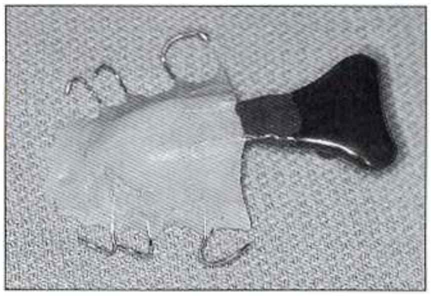


Fig 9-8 Compound has been incrementally extended to the point of completely occluding the nasal airway. Reduction of the lateral extensions will determine whether residual muscle activity can close the lateral ports during speech.

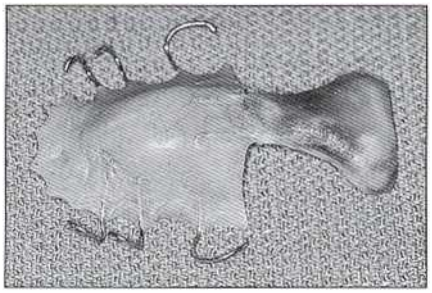


Fig **9-9** The lift has been reduced, coated with mouth-temperdture softening wax, and worn by the patient for approximately 5 minutes. There are no obvious areas where the compound is overextended, and the lift is ready for processing into acrylic resin.

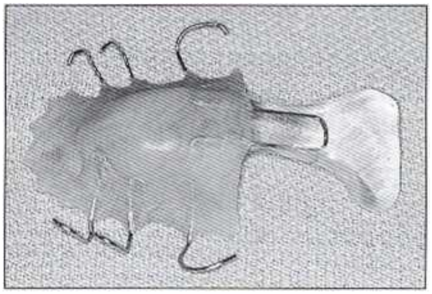


Fig 9-10 Completed palatal lift prosthesis.

evaluation of speech is the primary assessment method, one should assume that additions to and subtractions from the lateral borders of the lift will be most likely to result in maximum reduction of hypernasality and the best chance of residual patent nasal airway.

The final step in lift generation is to reduce the entire surface of the compound by 1 to 2 mm. Mouth-temperature softening wax is applied in sufficient amount to replace lost compound, and the lift is tempered and reinserted. The patient is asked to speak, swallow water, and move the head in all directions to form the wax.

The lift is removed after approximately 5 minutes and evaluated carefully for thin areas that might indicate excessive pressure on soft tissue. If thin areas are found, the underlying compound is scraped to reduce it further, wax is reapplied, and the lift is placed back in the mouth for an additional 5 minutes (Fig 9-9).

Following the lift-generation session, the lift portion of the device is replicated in acrylic resin. It is carefully finished and polished to ensure that there are no residual rough or sharp edges that might lacerate the distended soft palate mucosa (Fig 9-10).

Insertion and Patient Instructions

During the insertion appointment, the effectiveness of the lift is again confirmed. The lift can be evaluated for excessive pressure by using a pressure-sensitive paste. Care should be taken in arbitrarily reducing the size of the lift at this stage, as a properly functioning lift will demonstrate significant pressure on the soft palate and the disclosing medium will reflect moderate pressure. Only those areas of obviously heavy pressure should be reduced and repolished.

The patient should be seen within 2 or 3 days of delivery of the palatal lift. While use of the lift can be discontinued if the patient experiences soreness, the sensory innervation of the mucosa covering the soft palate may not discern soft tissue irritation due to excessive pressure from the lift. Evaluation of the soft palate by the prosthodontist should be scheduled to ensure that mucosal irritation caused by the lift is minimal and adjusted at an early stage.

It is critical that the patient is able to insert and remove the palatal lift easily. If not, it is even more critical that the person(s) responsible for inserting and removing it will be present with the patient whenever it is worn. If the patient becomes ill or for any reason wants to remove the lift, the means to do so should always be available. Usually, the lift is worn constantly during the waiting hours. If, however, the lift was fabricated to completely occlude the nasal port, making the patient a mouth breather, the patient may prefer to wear the lift only in situations where speaking is anticipated. Patients with residual nasal airway with the lift in place may accommodate its presence and be quite comfortable with the lift. Others may use it only sparingly when speech with people not accustomed to hearing the patient speak with hypernasality is required.

The value of eating with the lift in place is also something the patient will have to determine. Some will find it more comfortable to eat without the lift, but it should be understood that for many palatal lift patients food leakage into the nose is not a problem, and the value of the palatal lift for such patients is only for speech. The patient whose palatal lift completely occludes the nasopharyngeal passage will rarely tolerate the lift during eating, as nasal airflow is necessary for the olfactory portion of taste.

The patient should not wear the lift while sleeping, to allow the mucosa of the palate to recover from the coverage and pressure caused by the lift. While not common, supraeruption of the clasped abutment teeth could conceivably be a concern, particularly when substantial pressure is required to keep the soft palate elevated. Removal of the lift at night would reduce the amount of time that the abutment teeth are under eruptive orthodontic forces.

Outcome Evaluation

The success of any prosthesis or oral device is measured by how well it solves the problem for which it was prescribed. In the case of a palatal lift, the outcome is measured by the speech professional involved and the patient, who determines the value of the inconvenience and discomfort of the lift to the perceived improvement of speech function. It is not uncommon that a palatal lift satisfies all of the indications for which it was fabricated but still is not successful because of the inability or unwillingness of the patient to use it. Lack of compliance is a common problem, but one must appreciate that the palatal lift intrudes on the oral cavity of the patient, often causing discomfort. Recognition of the improvements in speech intelligibility is the primary motivation for a patient to wear a palatal lift.

LaVellc and Hardy (1979) defined three satisfactory outcomes for palatal lift prostheses:

> An *optimal* result occurs when the prosthesis results in palatopharyngeal port closure during speech production except in association with production of nasal consonants; that is, the resulting pattern of closure would be essentially normal. The result is considered *successful* when there is palatopharyngeal closure throughout speech production. These patients generally end up hyponasal with their prosthesis in place. This is because they arc fully closed and are not able to get airflow when saying their nasal sounds such as «, *n* and *ng*. The

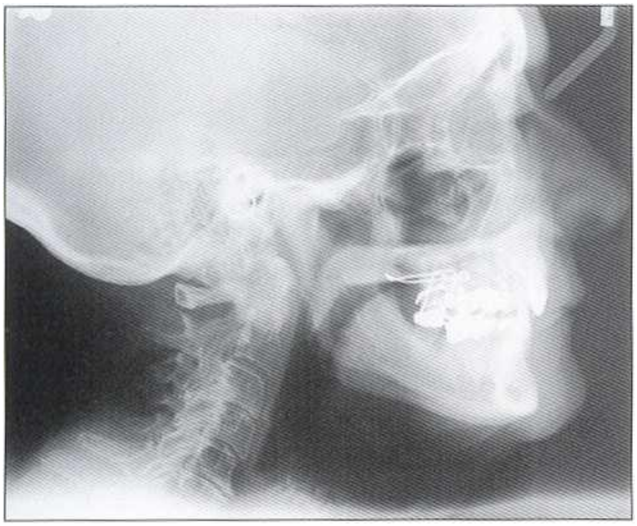


Fig 9-11 Lateral cephalometric radiograph of the patient shown in Fig 9-1 with a completed palatal lift in place. The lift is successful primarily due to the residual muscle activity the patient is able to utilize for palatopharyngeal closure. The lift allows her to breathe normally while positioning the soft palate closer to the level necessary to create closure for speech.

> result is considered only *desirable* when the palatopharyngeal port area is reduced so that incompetency is a relatively minor speech physiology problem.

These patients are still slightly hypernasal because the prosthodontist was unable to apply adequate lifting pressure in the optimal location to completely occlude the palatopharyngeal port.

Conclusion

The purpose of a palatal lift prosthesis is to obtain velopharyngeal closure by displacing the soft palate to the level of normal palatal closure at the palatal plane (Fig 9-11). Once the soft palate is elevated, the pharyngeal walls ideally can complete closure of the nasopharyngeal port. For a palatal lift to work effectively there must be some residual movement of the pharyngeal walls. The goal is to obtain a reduction in the size of the palatopharyngeal opening with a subsequent decrease in nasality. This in turn will allow increased oral air pressure necessary for intelligible articulation.

Ongoing speech therapy is frequently necessary and encouraged for patients receiving palatal lifts. It is not uncommon to sec further improvement in speech intelligibility several weeks after placement of a palatal lift. It is also common to encounter patients whose neurologic deficits include speech problems other than hvpernasality. While palatal lift therapy for the young patient with a repaired (or occult) palatal cleft and residual hypernasality can benefit from the stimulatory effect of a palatal lift and might even ultimately discontinue its use, most patients referred for palatal lift therapy have neurologic deficits that are not likely to improve with lift placement.

References

Beery Q, Aramany M, Katzenberg B. Oral endoscopy in prosthodontic management of the soft palate defect. J Prosthet Dent 1985;54:24-1.

Beery Q, Rood S, Schramm V. Pharyngeal wall motion in prostheticallv managed cleft palate adults. Cleft Palate J I983;20:7. '

Gibbons P, Bloomer H. A supportive-type prosthetic speech aid. 1 Prosthet Dent 1958;8:362.

Gonzalez JB, Aronson AK. Palatal lift prosthesis for treatment of anatomic and neurologic palatopharyngeal insufficiency. Clef Palate J 1970;7:91-104.

Kipfmueller L, Lang B. Treating velopharyngeal inadequacies with a palatal lift prosthesis. I Prosthet Dent 1972;27:63.

LaVelle W, Hardy J. Palatal lift prostheses for treatment of palatopharyngeal incompetence. J Prosthet Dent 1979; 42:308.

Mazaheri M, Mazaheri EPI. Prosthodontic aspects of palatal elevation and palatopharyngeal stimulation. J Prosthet Dent 1976;35:319-326. '

Skolnick M, McCall G, Barnes M. The sphincteric mechanism of velopharyngeal closure. Cleft Palate J 1973; 10:286.

Turner G, Williams W. Fluoroscopy and nasoendoscopy in designing palatal lift prostheses. J Prosthet Dent I991;66:63.

Warren D, Dalston R, Dalston E. Maintaining speech pressure in the presence of velopharyngeal impairment. Cleft Palate) 1990;27:53.

Witt PD, Rozelle AA, Marsh JL, et al. Do palatal lift prostheses stimulate velopharyngeal neuromuscular activity? Cleft Palate Craniofac J 1995;32:469.

Wolfaardt J, Wilson F, Rochet A, McPhee L. An appliance based approach to the management of palatopharyngeal incompctcncy: A pilot project. J Prosthet Dent 1993; 69:186.

Yorkston K, Honsinger M, Beukelman D, Taylor T. The effects of palatal lift fitting on the perceived articulatory adequacy of dysarthric speakers. In: Yorkston K, Beukelman D (eds). Recent Advances in Clinical Dysarthria. Boston: College-Mill, 1989: Chapter 4.

The Impact of Endosseous Implants on Maxillofacial Prosthetics

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Alterations in maxillofacial anatomy result in diverse physical and emotional responses from the patient (Rozcn et al, 1972; Gillis et al, 1979). The reasons for these responses are varied, blit cosmetic changes, loss of function, and discomfort are usually the major sources of concern.

It is unlikely that any prosthetic replacement can duplicate what nature provides from either a cosmetic or a physiologic standpoint. Cosmetically there must be matches in hue, chroma, and value of the lost tissue while also considering tissue translucency, texture, size, shape, and contour. Placement of a prosthesis in the focal point for most human contact, the face, serves to complicate the matching process even more. When the societal emphasis on physical appearance is considered, it is evident that maxillofacial defects have the potential to be emotionally traumatizing.

The physiologic function of natural structures cannot be completely duplicated. In some instances, such as in the prosthetic replacement of an eye, all function is lost, whereas in other instances, such as the replacement of a single missing tooth, there is little functional deficit. Prediction of the functional deficit prior to surgical excision of a diseased structure is complicated by the presence of a disease process that in and of itself creates a functional deficit. Pre-existing disease limits function because it often compromises anatomy. Removal of a diseased structure will normally result in further functional loss, but such a loss is not always the case. The exception occurs when the normal anatomy is so altered by disease that it cannot function naturally. In such situations, the removal of the diseased structure may be regarded as a relief to the patient rather than a handicap.

The human body is remarkably complex. Every tissue is dependent upon another tissue if normal physiologic function is anticipated. The skeleton without ligaments, muscles, and cartilage cannot remain erect. Musculature without a controlling nervous system is unable to perform purposeful activity. When considering the maxillofacial complex as an integrated system, it is clear that disruption of any of its components has an effect on all of the remaining components. Physiologic deficits are easily understood since there are outward signs of the deficit, but patient comfort is not easily perceived by an observer. When treating patients with maxillofacial defects, it is prudent for the clinician to anticipate altered sensations that may be difficult to overcome with conventional prosthetic methods. Patients should be provided with prostheses that are comfortable and do not cause tissue irritation. Retention that is dependent upon frictional contact can result in irritation that may cause alteration in the residual anatomy.

The prosthodontist assumes responsibility for the fabrication of prostheses that provide function, esthetics, and comfort. As defects increase in size or as the number of involved structures increase, the task of the prosthodontist increases in complexity (Zarb, 1967; Parr et al, 1989). Optimal care is provided if residual anatomy is used appropriately.

Primary Factors that Affect Prosthetic Success

All prostheses must resist a variety of forces that may displace the prosthesis and generate stress to the residual structures of the orofacial complex. Forces may be directed toward, away from, or at an angle to the supporting structure. Prosthesis success is often dependent upon the use of methods of compensation for diminished anatomic capacity for support, retention, and stability of a prosthesis.

In order to achieve a favorable level of retention, remaining teeth and the remaining soft and hard tissues must be used to the optimal degree. It is prudent to extend impressions as much as possible without interfering with movable tissue. Border molding is performed whenever a prosthesis depends upon tissue support whether that tissue is located within the defect or is part of the remaining normal structures. In addition, close adaptation to the underlying tissue results in a thin fluid film between the prosthesis and the tissue. According to the Stanitz (1948) equation, the thinner the intervening fluid, the greater the prosthetic retention.

Support is the ability to resist displacement of the prosthesis toward the underlying structures. Remaining teeth, remaining edentulous areas, and the postsurgieal defect are the supporting tissues for the prosthesis, and prosthesis loads are generated through these tissues to the underlying supporting bone. Because the tissue has limited capacity for displacement, the greater the surface area of tissue contact, the less the displacement of the prosthesis toward the tissue. In this situation, maximum peripheral extension combined with an accurate adaptation to the remaining teeth, the residual ridges, and the postsurgieal site will provide the most favorable support for a prosthesis.

Resistance to forces that are neither directed toward the tissue nor directed away from the tissue is provided by the remaining teeth, the residual ridges, and the surgical site itself. This characteristic of a prosthesis is called stability, the physical force that is called upon most frequently in maxillofacial prosthetics because alteration in the normal structures results in diminished potential for support and retention. Because the majority of forces are not directed toward or away from the tissue but generated at an angle to the tissue, it is stability that is tested most fre- quently in function.

Residual anatomy, in the form of teeth, residual ridges, or the contours of the defect, may provide retention, support, and stability to maxillofacial prostheses. With distortion or loss of normal anatomic structures, the ability to maximize these goals is diminished. When teeth are lost, prostheses generally lose capacity to fulfill the stated objectives of comfort, function, esthetics, and preservation of the residual anatomy. As functional demands are placed on the residual anatomy, further deterioration of the underlying foundation is frequently seen. Atwood (1971) described the chronic, progressive, and relentless deterioration of the underlying structures relative to the use of complete dentures, but this structural loss may be even more evident when maxillofacial prostheses are needed.

Historically, the continuing loss of supporting structures left patients with increasing levels of physiologic and cosmetic deficiency. Compensation for unfavorable anatomy generally requires surgical alteration of the defect area, alternative methods of external fixation, mechanical engagement of tissue undercuts, or the use of denture or skin adhesives. Although these methods have been beneficial when alternatives do not exist, none of them has been absolutely predictable (Firtell et al, 1976).

An alternative method of prosthetic anchorage has been developed (Albrektsson et al, 1987; Parel and Tjellstrom, 1991). Endosseous implants may be used to address the concerns of diminished support, retention, and stability' (Fig 10-1).

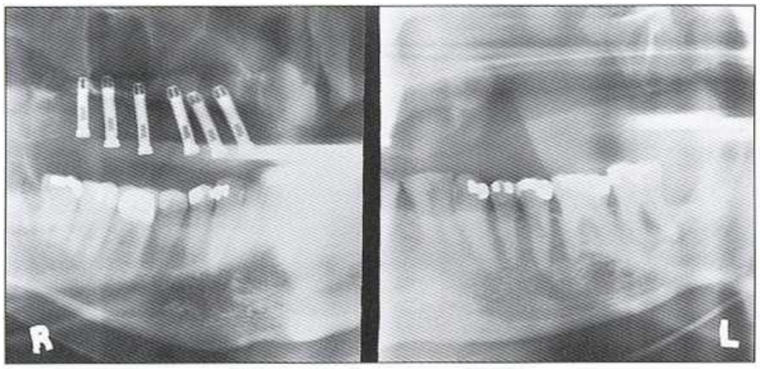


Fig 10-1 Endosseous implants in place in edentulous maxilla with left surgical defect.

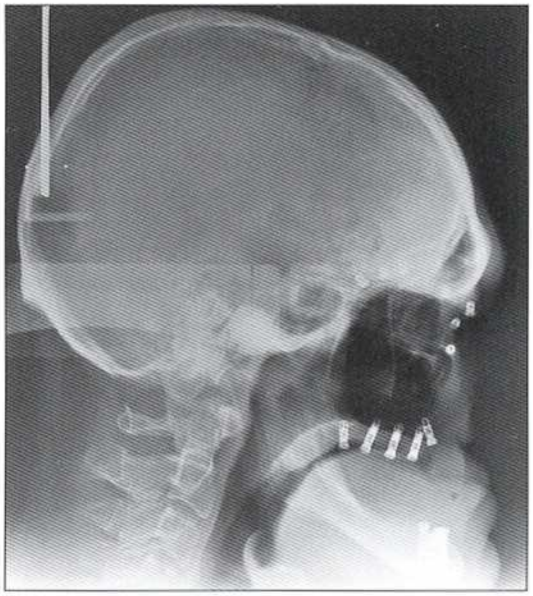


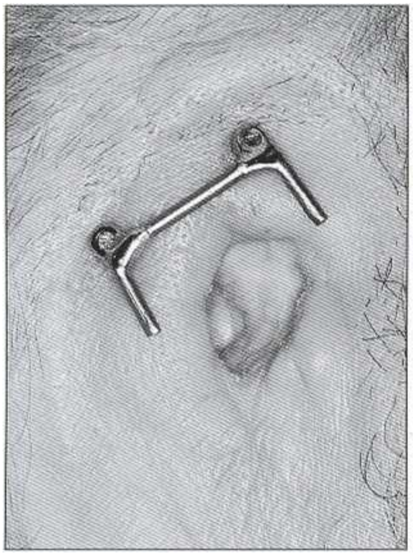
Fig 10-2 (*right*) Endosseous implants in place in the orbital region in addition to the maxilla and mandible.

Implants are placed into the residual bone and then used for retention, support, and stability of a prosthesis. Efficacy of implant support has been established in the restoration of edentulous and partially edentulous jaws, and it appears that similar responses are possible in congenital, developmental, and acquired maxillofacial defects (Adell et al, 1981; Branemark, 1983). Use of similar implants in extraoral sites is growing in popularity, especially for the retention of auricular prostheses and for bone-anchored hearing aids (BAHA) (Fig 10-2) (McComb, 1993; Wolfaardt et al, 1993; Van Waas, 1994).

Unfortunately, the use of endosseous implant support in maxillofacial defects can be complex. As seen in most maxillofacial prosthetic patients, alterations in normal anatomy reduce the opportunities for the clinician to place and restore endosseous implants. This situation occurs when supporting bone is lost due to surgical resection or when tissue is altered due to therapeutic modalities such as radiation.

Since endosseous implants lack clinical mobility', force equalization and compensation for prosthesis displacement, clinical use of these implants may be difficult. Prosthetic designs and strategic implant placement must anticipate the functional demands of the prosthesis while also recognizing the dislodging forces applied to it. Excessive force on the implants is possible since masticatory forces are generally applied to nondefect areas of the jaw that may also be the only possible location for implant placement. With limited area for implant placement, there is a risk of lateral force application. Such forces may be implicated in bone and implant loss, and are clearly damaging to prosthetic retaining screws and components (Langer and Sullivan, 1989; Sones, 1989; Zarb and Schmitt, 1993a; Zarb and Schmitt, 1993b).

When considering maxillary defects, implants are of great benefit in providing retention, but their use for support and stability may be risky. Because dislodging forces can be anticipated, the design of the prosthesis is modified to resist these forces. Since the fracture strength of the implant components should be known to the clinician, it is reasonable to design the prosthesis to provide retention below the level of component breakage and to disengage before breakage is likely. Unfortunately it is difficult to anticipate the occlusal forces of patients, especially when these forces may not be generated in the long axis of the implant (Marunick et al, 1992; Wedel et al, 1994). Mastication could provide forces that exceed the physical properties of the implant or the prosthetic components.



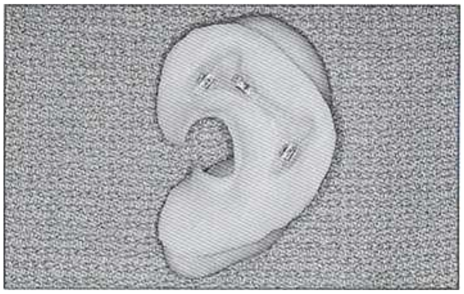
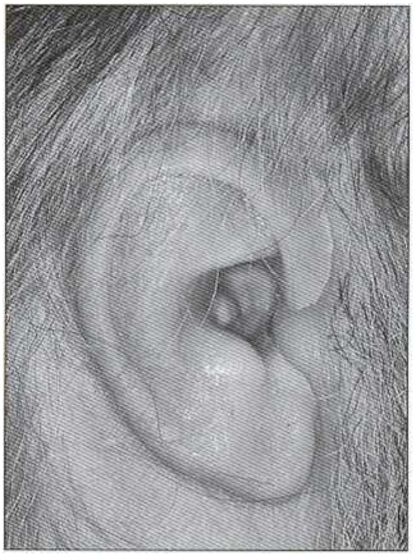


Fig 10-3a *(left)* Endosseous implants and bar splint in place to retain an auricular prosthesis.

Fig 10-3b (*center)* Internal surface of auricular prosthesis. Note retentive clips in place in an acrylic resin superstructure, which is included within the auricular prosthesis.

Fig 10-3c *(right)* Auricular prosthesis in place.



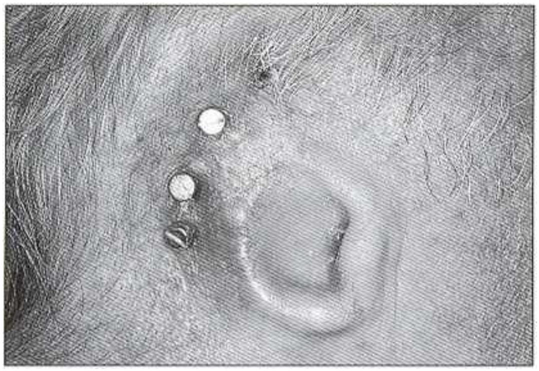


Fig 10-4 Localized skin inflammation around endosseous implant abutments.

With extraoral defects, support and stability of the prosthesis are unlikely to overstress the implants. Similarly, retention of an extraoral prosthesis is limited to the resistance of gravitational forces (Tolman and Desjardins, 1991; Wolfaardt and Wilkes, 1994). The weight of the prosthesis, mass times gravity, must be resisted by the retentive features to prevent dislodgment of the prosthesis. In addition, dynamic movement must be resisted. Movement of the head, jaws, and facial musculature must be considered, but none of these forces approaches the levels of force encountered with intraoral prostheses. Therefore, extraoral prostheses supported by endosseous implants should require a reduced number of implants relative to prosthesis size when compared to intraoral prostheses.

Auricular Prostheses

Prosthetic replacement of a missing or altered ear can provide excellent cosmetic results. Unfortunately, the presence of hair and the absence of anatomic irregularities often result in unfavorable adhesive retention of an auricular prosthesis. Alternatively, endosseous implants specifically designed to be placed in the temporal bone permit positive retention (Fig 10-3). Patients also benefit from the positive seating of the prosthesis over the implants. The main complication in this area is related to the difficulty in maintaining adequate hygiene around the skin-penetrating implants (Fig 10-4). Holgcrs et al (1987) report adverse tissue reactions in approximately 11% of patients receiving these implants. Although soft tissue reactions rarely jeopardize the long-term survival

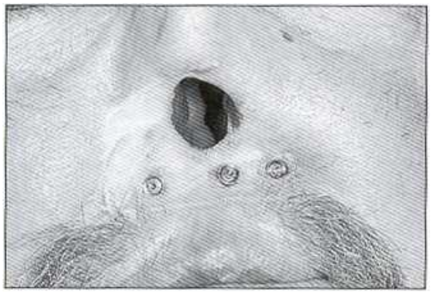


Fig 10-5a *(above)* Endosseous implants in place in superior surface of maxilla for retention of a nasal prosthesis.

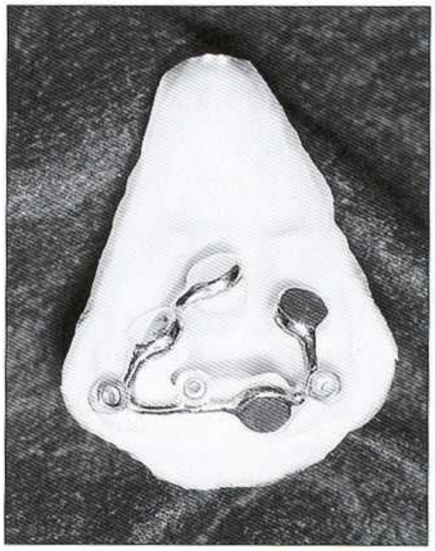


Fig 10-5b (*center*) Internal surface of prosthesis with bar splint and magnet pods.

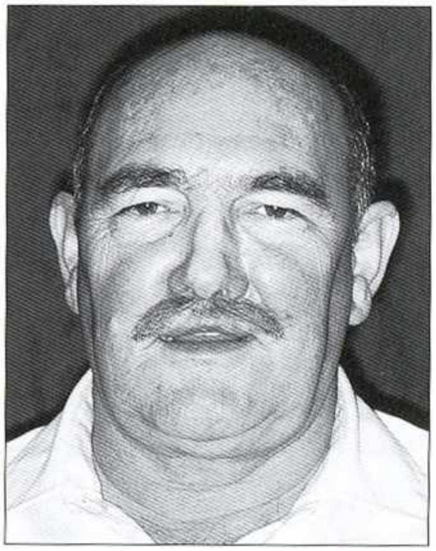


Fig 10-5c *(right)* Final prosthesis in place. (Photographs courtesy of Dr Stephen Parel.)

of the implants, they can create uncomfortable situations that may require surgical intervention and, at the least, increased hygiene needs (Gitto et al, 1994).

Endosseous implants may also be used to secure bone-conduction hearing aids. BAHAs have demonstrated efficacy in patients with intact middle-ear components but with damaged external ear structures (Granstrom and Tjellstrom, 1997; Wazen et al, 1998).

Nasal Prostheses

Nasal resection is a highly variable treatment. Surgical margin extension is different for every patient, making general statements regarding the use of implants in this area difficult. Clearly, the total or near-total resection of the nose creates difficulties for the maxillofacial prosthodontist. Prostheses must be extended to surrounding areas to provide for skin adhesive retention, making these prostheses large and susceptible to dis- lodgment during physical activity. Engagement of the defect itself may be possible only if highly resilient materials are used for this purpose. Implant success is highest when implants are placed into the superior surface of the maxilla and used to retain the inferior aspect of the nasal prosthesis (Eig 10-5) (Nishimura et al, 1996). Unfortunately, the bone quantity and quality in the glabellar region of the frontal bone is limited, and implants at the superior aspect of a nasal defect usually cannot be placed. Because implant retention is possible at the inferior aspect of the prosthesis only, it is critical that the design of the retentive elements of the prosthesis incorporate two planes of retention. Generally a U-shaped retentive bar connected to the implants at the base of the U will provide three points for retention: the two vertical struts and the horizontal crossbar. Retentive clips or magnets are used to secure the prosthesis.

Orbital Prostheses

Small orbital defects may not be suitable for implant-supported restorations. In smaller defects, adhesive retention of the prosthesis may be satisfactory and the limited size of the defect may prevent implant placement without interference in the prosthesis margins (Brown, 1969; Andres et al, 1992; DaBreo and Schuller, 1992). As orbital defects increase in size, the need for implant support becomes greater (Eig 10-6). This need is particularly true when orbital defects are confluent with facial and nasal defects. In those situa-

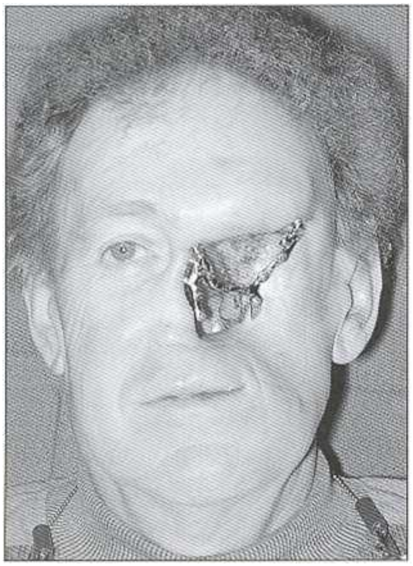


Fig 10-6a *(left)* Lateral orbital and nasal implants in place with bar splint and magnet pods.

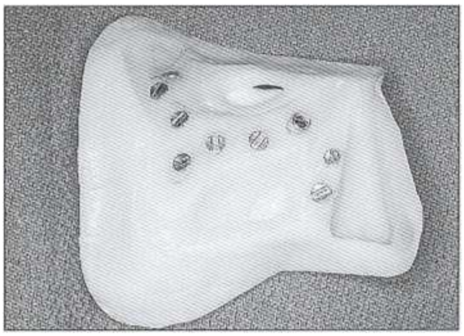


Fig 10-6b *(above)* Internal aspect of prosthesis with magnets in place.

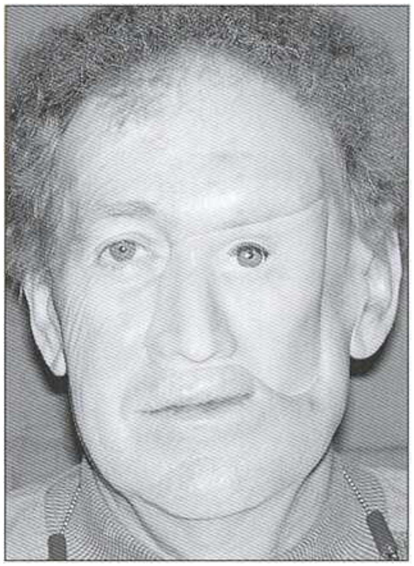


Fig 10-6c *(right)* Combined orbital-nasal prosthesis in place.

tions, the implants arc generally located in the supraorbital rim or in the lateral rim of the residual orbit. Medial placement of the implants is discouraged due to diminished bone quantity and quality in this area and the associated reduced implant survival rates in bone of low quality (Lundgren et al, 1993; Nishimura ct al, 1998).

Mandibular Defects

Mandibular discontinuity subsequent to ablative tumor surgery is effectively managed by immediate or delayed surgical reconstruction to re-establish continuity (Figs 10-7 and 10-8). The reconstructed mandible will be edentulous in the graft site. Endosseous implants in this grafted bone will allow the placement of a dental prosthesis that does not create deleterious compressive forces on the graft (Fig 10-9) (Keller et al, 1988). Internal loading of the graft results in bone preservation, a situation that would otherwise not occur if mucosal loading over the bone were to occur.

If mandibular continuity is not re-established, the functional capacity of the patient is diminished (Marunick et al, 1992). The mandible will deviate toward the side of the resection because of cicatricial changes in the surgical site and because of absent musculature on that side. This treatment group also shows a high level of functional variability, but patients with good control of the residual mandible generally perform better than patients who lack such control. As patients experience tooth loss, management of removable prosthescs in conjunction with manipulation of the residual mandible may prove difficult. In these situations, the use of endosseous implants is quite effective, since dental prosthescs will gain retention, support, and stability from the implants. Force application to the implants must, however, be considered carefully.

The resected mandible that has not been reconstructed will have a deviated opening and closing arc (Fig 10-10). The angle of mandibular closure will place forces on the implants that arc not in line with the long axis of the implants. This situation is offset somewhat by the fact that maximum occlusal force of the resected mandible is diminished from normal. Clinical experience with fixed-implant-supported mandibular resection prosthescs has shown promising results despite concerns over angular force application.

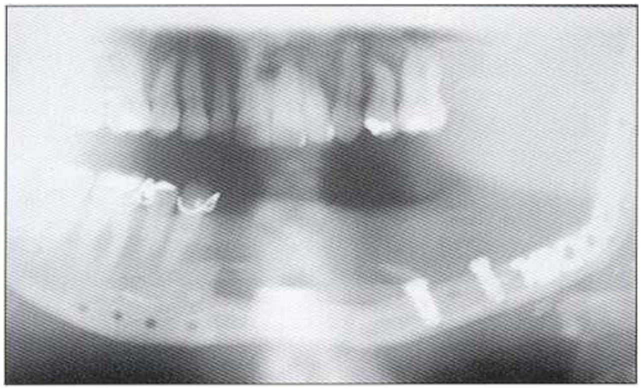


Fig 10-7 *(above)* Immediate reconstruction of the mandible with fibula graft and subsequent placement of dental implants.

Figs 10-8a and 10-8b *(right)* Delayed reconstruction of the mandible with subsequent placement of dental implants, with view of prosthesis in place.

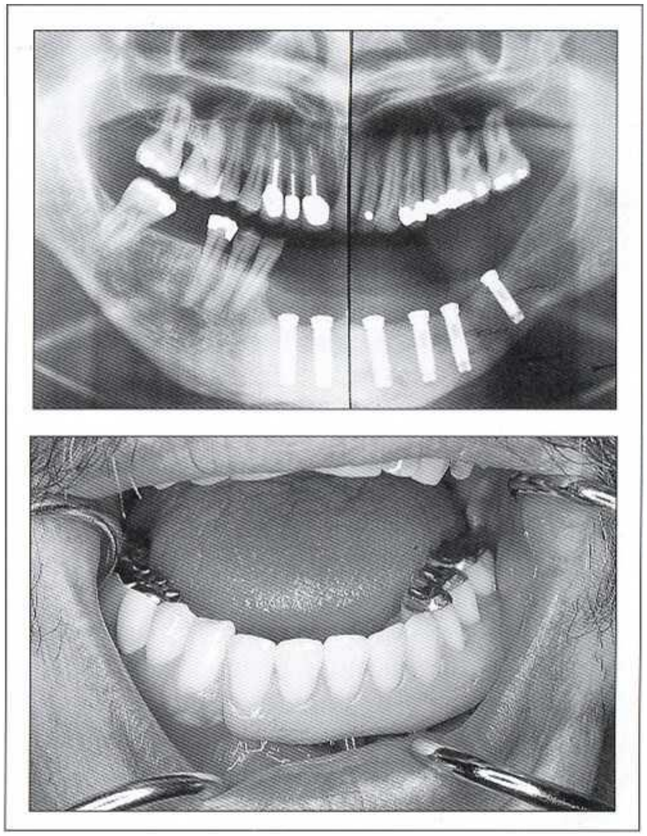
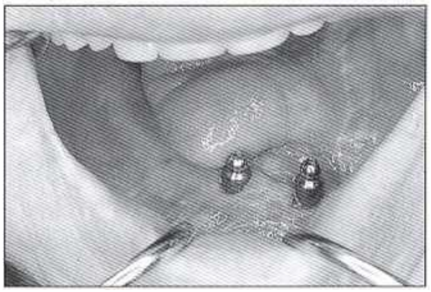
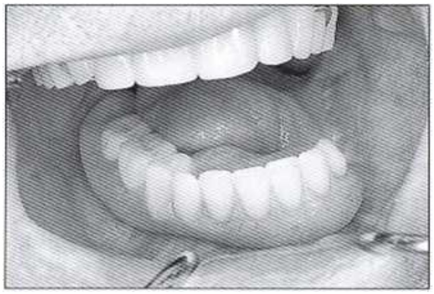


Fig 10-9a *(left)* Two implants in mandible with discontinuous defect. Note deviation of mandible toward defect.

Fig 10-9b *(right)* Overdenture in place.





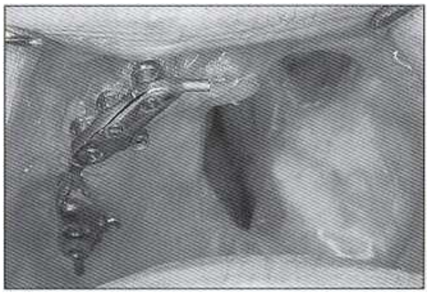


Fig 10-10a Abutments and bar splint in place on endosseous implants shown in Fig 10-1.

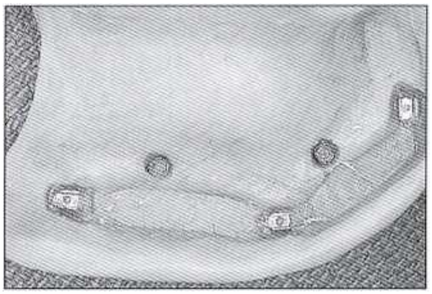


Fig 10-10b Internal surface of obturator prosthesis with retentive clips in place and additional sites available for attachments if needed.

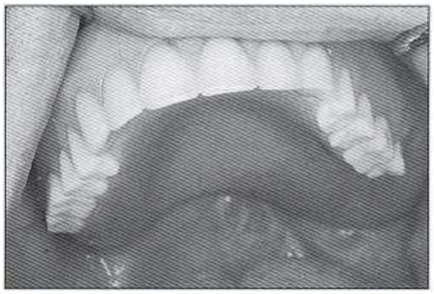


Fig 10-10c Prosthesis in place,

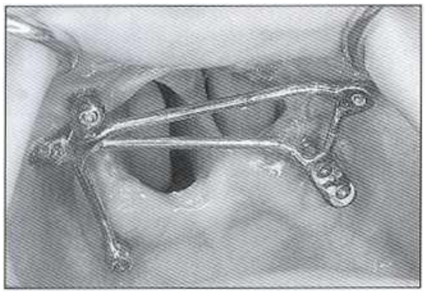


Fig 10-1 la Bilaterally placed implants in maxillary defect with bar splint in place.

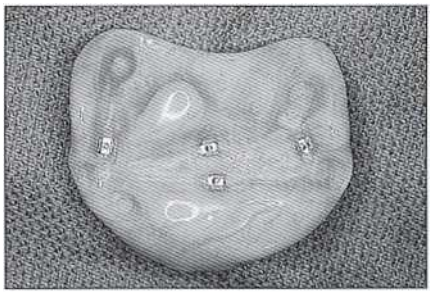


Fig 10-1 lb Internal surface of obturator prosthesis with retentive clips in place.

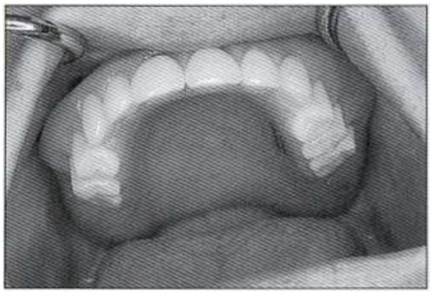


Fig 10-1 lc Obturator prosthesis in place.

Hard and Soft Palate Defects

Surgical resection of tumors in the maxilla often results in communication between the oral and nasal cavities. These communications must be closed if the patient is to experience normal or near-normal functions of phonation, deglutition, and mastication. Obturator prothescs supported and retained by the residual natural dentition have a long history of successful clinical application. Loss of supporting teeth, however, results in compromises in prosthetic retention and support. Relatively large obturator prostheses place substantial forces on the residual structures. When implants are used to retain such prostheses, it is essential that the different forces be considered (Figs 10-10 and 10-11). These prostheses have a tendency to rotate into the defect area when occlusal loads are placed on the defect side but to rotate out of the defect area as gravity exerts its pull on the prosthesis (Brown, 1968). Although it is possible to gain support and retention within the defect, it is often less satisfactory than might be hoped.

Endosseous implants in residual maxilla must be of sufficient number, length, and distribution to resist the anticipated complex forces of mastication and dislodgment. Four implants in the intact maxilla has been suggested as the minimum number for support of overdenture prostheses (Roumanas et al, 1997). The force distribution in the patient with a hard palate defect is likely to be less favorable than in the edentulous maxilla; consequently, it is prudent to consider four or more implants when an obturator prosthesis is to be retained and supported by endosseous implants. If the implants can be distributed bilaterally, more acceptable forces will be generated to the implants and better retention and stability will be achieved.

Soft palate defects are normally associated with bilateral maxillary support. Once again, as natural teeth are lost, implants may improve prosthesis prognosis. Since occlusion is not a consideration in soft palate defects, the primary function of implants is to retain the prosthesis and to support the occlusion that is more directly placed above the implants themselves. Implant placement should consider retention and indirect retention of the prosthesis, with broad distribution of implants providing a more favorable long-term prognosis.

Conclusion

Patients with facial or intraoral defects will seek treatment to address the loss of comfort, function, or natural appearance. It is the maxillofacial prosthodontist’s responsibility to provide prostheses that do not injure the remaining structures. As anatomy is altered, demands placed on residual structures increase. Endosseous implants may be used to provide retention, support, and stability for maxillofacial prostheses when the residual anatomy is no longer capable of fulfilling these functions.

References

Adcll R, Ixkholm U, Rockier If, Brancmark P. 15-vear study of osscointegrated implants in the treatment of the endentulous jaw. Int J Oral Sing 19S1; 10:387.

Albrektsson T, Brancmark P, Jacobsson M, Tjellstrom A. Present clinical applications of osscointegrated percutaneous implants. Plast ReconstrSurg 1987;79:721.

Andres C, Newton A, Schriever J, Shore J. Orbital prosthe- ses following temporal muscle or forehead flap reconstruction: Use of optics and illusions. J Prosthet Dent 1992;67:390.

Atwood D. Reduction of the residual ridges: A major oral disease entity. J Prosthet Dent 1971;26:266.

Brancmark P. Osseointegration and its experimental background. J Prosthet Dent 1983;50:399.

Brown K. Fabrication of orbital prosthesis. J Prosthet Dent 1969;22:592.

Brown K. Peripheral considerations in improving obturator retention. J Prosthet Dent 1968;20:176.

Da Breo E, Schuller D. Surgical and prosthodontic considerations in the management of orbital tumors. J Prosthet Dent 1992;67:106. "

Firtell D, Oatis G, Curtis T, Sugg W. A stent for a split thickness skin graft vestibuloplasty. J Prosthet Dent 1976; 36:204.

Gillis R, Swenson VV, Laney W. Psychological factors in volved in maxillofacial prosthetics. J Prosthet Dent 1979; 41:183.

Gitto G, Plata W, SchaafN. Evaluation of the peri-implant epithelial tissue of percutaneous implant abutments supporting maxillofacial prostheses. Int J Oral Maxillofac Implants 1994;9:197.

Granstrom G, Tjellstrom A. The bone-anchored hearing aid (BAHA) in children with auricular malformations. Ear Nose Throat J 1997;76:238.

Holgers K, Tjellstrom A, Bjiirsten L, Erlandsson B. Soft tissue reactions around percutaneous implants. A clinical study on skin-penetrating titanium implants used for bone-anchored auricular prostheses. Int J Oral Maxillofac Implants 1987;2:35.

Keller B, Desjardins R, Eckert S, Tolman D. Composite bone grafts and titanium implants in mandibular discontinuity reconstruction. Int J Oral Maxillofac Implants 1988-3:261.

I .anger B, Sullivan D. Osseointegration: Its impact on the interrelationship of periodontics and restorative dentistry. Part I. Int J Pcriodont Restorative Dent 1989;9:89.

Eundgren S, Mov P, Beumcr J, Lewis S. Surgical considerations for endosseous implants in the craniofacial region: A 3-year report. Int J Oral Maxillofac Surg 1993;22:272.

Marunick M, Mathes B, Klein B, Scycdsadr M. Occlusal force after partial mandibular resection. J Prosthet Dent 1992;67:835.

McComb H. Osseointegrated titanium implants for the attachment of facial prostheses. Ann Plast Surg 1993; 31:225.

Nishimura R, Roumanas E, Moy P, Sugai T. Nasal defects and osscointegrated implants: UCLA experience. J Prosthet Dent 1996;76:597.

Nishimura R, Roumanas E, Moy P, Sugai T, Freymiller E. Osseointegrated implants and orbital defects: UCLA experience. J Prosthet Dent 1998;79:304.

Parel S, Tjellstrom A. The United States and Swedish experience with osseointegration and facial prostheses. Int I Oral Maxillofac Implants 1991;6:75.

Parr G, Tharp G, Rahn A. Prosthodontic principles in the framework design of maxillary obturator prostheses. J Prosthet Dent 1989;62:205.

Roumanas E, Nishimura R, Davis P>, Beumcr J. Clinical evaluation of implants retaining edentulous maxillary obturator prostheses. J Prosthet Dent 1997;77:184.

Ro/.cn R, Ordway D, Curtis T, Cantor R. Psychosocial aspects of maxillofacial rehabilitation. Part I: The effect of primary cancer treatment. J Prosthet Dent 1972;28:423.

Soncs A. Complications with osseointegrated implants.) Prosthet Dent 1989;62:581.

Stanitz J. An analysis of the part played by the fluid film in denture retention. J Am Dent Assoc 1948;37:168.

Tolman D, Desjardins R. Extra-oral application of osseointegrated implants. J Oral Maxillofac Surg 1991;49:33.

Van VVaas M. The future of extra-oral implantology. J Invest Surg 1994;7:333.

VVazcn J, Caruso M, Tjellstrom A. Long-term results with the titanium bone-anchored hearing aids: The U.S. expe lienee. Am J Otol 1998; 19:737.

VVedel A, Yontchev E, Carlsson G, Ow R. Masticatory function in patients with congenital and acquired maxillofacial defects. J Prosthet Dent 1994;72:303.

Wolfaardt J, Wilkes G. Craniofacial osseointegration. J Can Dent Assoc 1994;60:805.

Wolfaardt J, Wilkes G, Parel S, Tjellstrom A. Craniofacial osseointegration: The Canadian experience. Int J Oral Maxillofac Implants I993;8:197.

Zarb G. The maxillary resection and its prosthetic replacement. J Prosthet Dent 1967;18:268.

Zarb G, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants in anterior partially edentulous patients. Int-J Prosthodont 1993a;6:180.

Zarb G, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants in posterior partially edentulous patients. Int J Prosthodont 1993b;6:189.

Diagnostic Considerations for Prosthodontic Rehabilitation of the Mandibulectomy Patient

o Thomas D. Taylor, DDS, MSD

The most difficult aspects of clinical dentistry to teach or to learn arc diagnosis and treatment planning. Nowhere is the complexity and range of possible choices greater than when dealing with patients who have undergone surgical resection or traumatic loss of part of the mandible and require prosthodontic rehabilitation. The need to provide the mandibulectomy patient with an accurate prognosis for treatment that may involve multiple additional surgical procedures, significant morbidity, and outcomes frequently less desirable than anticipated is critical to the patient’s decision-making process for committing to the treatment plan. Curtis and Cantor (1974) addressed this topic in depth in a classic paper; 25 years later the problems associated with treatment planning for the mandibulectomy patient remain the same, but new knowledge about how cancer treatment is performed, improved radiographic diagnostics, and new rehabilitative treatment options have made the diagnosis and treatment planning for these patients even more complex than in the past. These problems were particularly well described in a recent paper by Marumck and Roumanis (1999).

This chapter systematically reviews a number of the factors that must be considered when attempting to determine the appropriate path for planning treatment for these most challenging patients.

Location and Extent of the Mandibular Defect

An obvious diagnostic determinant that must be considered initially is the extent of the postsurgi- eal defect requiring rehabilitation. A resection of the alveolar process without loss of mandibular continuity is not likely to result in as disabling or disfiguring a defect as one would anticipate following a resection involving loss of continuity of the mandible (Figs 11-1 and 11-2), nor would it be likely to present a treatment situation as challenging as anticipated if continuity of the mandibular body were lost. Problems associated with the treatment of the alveolar resection patient without loss of continuity are usually of less magnitude than those faced when continuity is lost, although this depends on many other factors as well, including the size of the defect and its location in the arch. The radical alveolectomy can present challenges to rehabilitation due to loss of vertical ridge height and vestibular depth. 'Phis can cause a reduction in stability for soft tissue-supported prosthcscs as well as the loss of load-bearing tissues available for support. One is frequently also faced with tethered border tissues that do not permit prosthesis border extension for maximum retention, support, and stability. The radical alveolectomy also results in a vertical

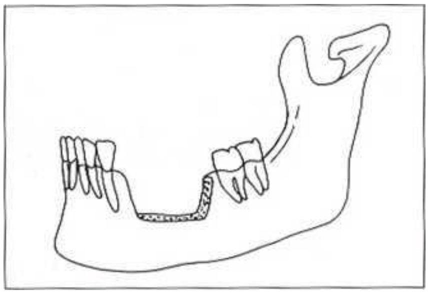


Fig 11-1 As a general rule, the resection of a portion of the mandible without loss of mandibular continuity is usually not as debilitating as a resection that compromises mandibular continuity, nor is such a limited resection as difficult to restore prosthodontically. (Reprinted with permission from Taylor et al, Chapter 36, in: Thawley et al |eds], Comprehensive Management of Head and Neck Tumors [ed 2], © 1999 W, B. Saunders.)

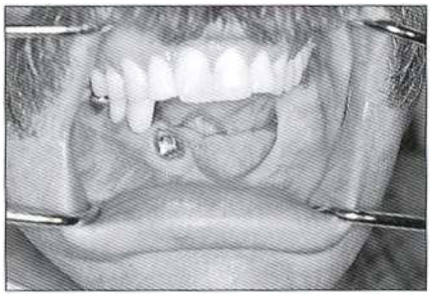


Fig 11 -2a A typical postsurgical result following marginal resection of the alveolar process of the mandible without loss of mandibular continuity. While the resulting defect is large and presents certain rehabilitative challenges, problems frequently seen with mandibular resections that compromise mandibular continuity are not usually seen with this limited type of resection. Mandibular deviation, altered occlusal relationships of remaining natural teeth, and other associated problems do not manifest themselves.

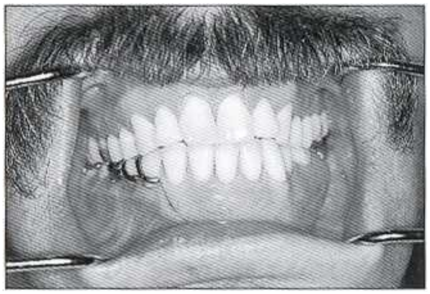


Fig 11-2b Removable partial prosthesis fabricated to restore lost hard and soft tissue. While the design and fabrication of such prostheses are somewhat different from routine removable partial denture service, the basic principles of support, stability, and retention remain the same and must be adhered to if a successful result is to be anticipated.

discrepancy between the level of residual osseous support and the opposing dentition at the level of the occlusal plane. This vertical discrepancy is of particular importance when prostheses supported by dental implants are being considered as part of the rehabilitative plan. The problems associated with these anatomic alterations will be discussed in more detail below because they also apply to the patient who has undergone resection followed by bone-graft reconstruction.

In situations where continuity has been lost, a simple rule of thumb that serves reasonably well for most situations is: the farther anterior the defect, the more disfiguring and functionally debilitating it is likely to be. Defects of the mandible that include the svmphyseal region will always require surgical reconstruction, or at least segment stabilization, before prosthodontic therapy can be effective (Fig 11-3). The reason that anterior defects are more debilitating functionally and difficult to treat prosthodontically relate to the loss of key muscle attachments (genioglossus, geniohyoid) located in the anterior mandible that control tongue function and mobility.

The patient who has undergone mandibulectomy involving the posterior mandibular body exhibits several postsurgical sequelae that will be discussed in the following paragraphs. Mandibulectomy defects of the molar region of the mandibular body are particularly well suited for surgical reconstruction (Fig 11-4). The mandibular defect in such cases requires a linear graft to restore continuity, linear grafts of the mandibular body are usually easier to perform than those requiring reconstruction of the anterior mandibular curvature and usually require a smaller graft to restore continuity. Defects of the molar region, when reconstructed surgically, are likely to result in near-normal mandibular mobility and functional movement, particularly when the elevator muscles of the defect side remain intact.

Fortunately, in recent years the increased use of immediate and delayed surgical reconstruction with bone grafts from various sites has made the mandibulectomy patient with a residual defect in mandibular continuity a less common case than was once seen. Surgical reconstruction of the mandible has solved some of the problems associated with prosthodontic rehabilitation but in many cases has created another set of problems to be dealt with. These too will be discussed further below.

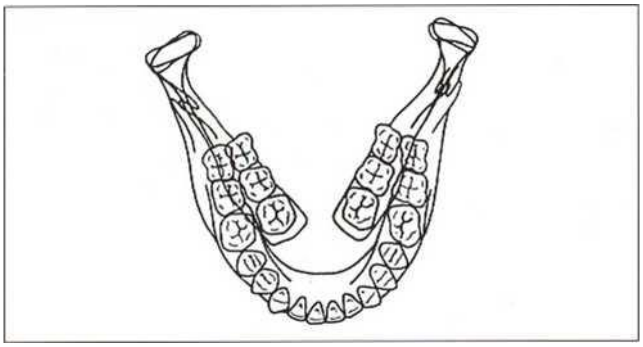


Fig 11-3a Resection of the anterior mandible is the most debilitating type of mandibulectomy because loss of the anterior mandible has the greatest impact on facial appearance and compromises function due to the loss of the ge- nioglossus and geniohyoid muscles. Prosthodontic rehabilitation in such situations is unlikely to be of any benefit without surgical reconstruction and segment stabilization. (Reprinted with permission from Taylor et al, Chapter 36, in: Thawley et al feds|. Comprehensive Management of Head and Neck Tumors |ed 2], © 1999 W. B. Saunders.)

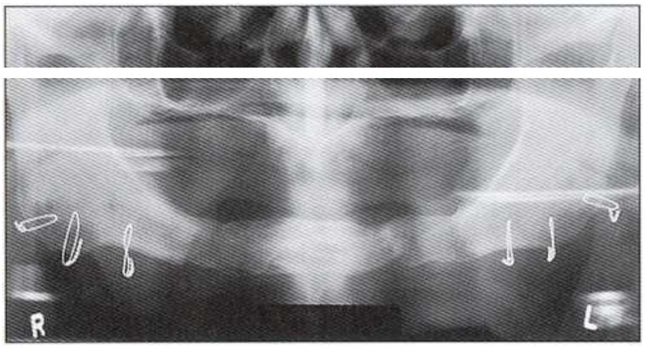


Fig 11 -3b Surgical reconstruction of the lost anterior mandible is prerequisite to prosthodontic treatment of the anterior mandibulectomy. Even following surgical reconstruction of mandibular continuity, as seen here, prosthodontic rehabilitation is not likely to be completely successful.

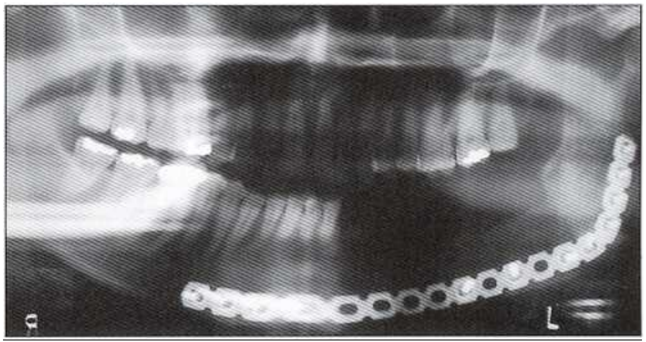


Fig 11 -4 Surgical reconstruction of the mandibular body/ ramus is of great benefit in creating a stable foundation for prosthodontic rehabilitation whether with endosseous implants or conventional removable prostheses.

Presence of Remaining Natural Teeth or Pre-existing Implants

The patient needing rehabilitation following mandibulectomy frequently presents with few or no remaining natural teeth. This can be partially explained by several observations. First, the patient at greatest risk for squamous cell carcinoma of the oral cavity is the heavy user of tobacco products and alcohol. The past lifestyle of these individuals may not have been conducive to a high level of oral hygiene, resulting in early tooth loss. In addition, there is a strong correlation between tobacco use and periodontal disease. Finally, teeth within the portals of planned radiation therapy with anything less than an excellent prognosis are frequently extracted prior to therapy to reduce the risk of future complication, particularly ostcora d ionecrosis.

The presence of remaining teeth or implants in the mandibular arch following resection may be the most important factor used to determine the prognosis of rehabilitative therapy. When even one or two teeth remain in the mandible, the patient is much more likely to tolerate a removable, tissue-supported prosthesis. The teeth are crucial to the stability of the prosthesis. Larger numbers of teeth remaining in the arch increase the prosthodontist's ability to design a restoration that maximizes the retention, stability, and support of the prosthesis. Teeth present on both sides of the midline permit greater prosthesis support because the problem of straight- line design can be avoided (Fig 11-5). Obviously, the more teeth remaining, the less traumatic the function of the prosthesis is likely to be. With the exception of small, short-rooted mandibular incisors, all remaining mandibular teeth should be incorporated into the design of the prosthesis,

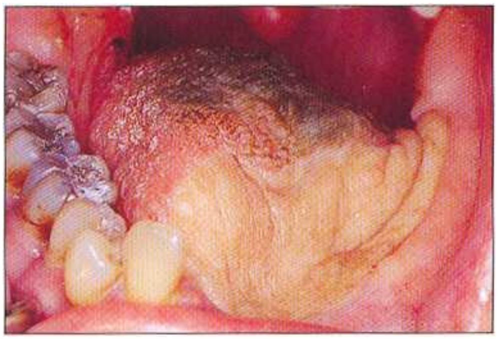


Fig 1 l-5a Remaining natural teeth in a linear relationship are not likely to be completely adequate abutments for a prosthesis replacing the missing structures in the area of the defect. Unfavorable position of the teeth relative to the planned prosthesis does not allow for adequate stability and retention. Support from the defect area is unlikely to be adequate except with surgical revision of the tongue/cheek closure of the surgical defect.

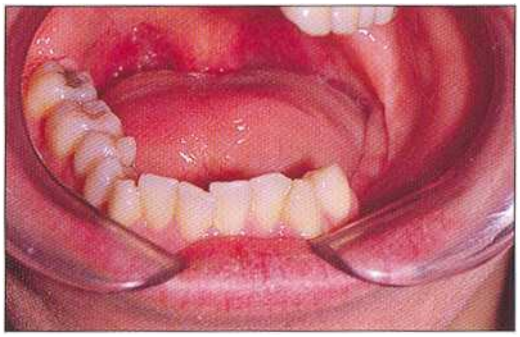


Fig 1 l-5b Prosthodontic rehabilitation in this situation is more likely to be successful due to the arrangement of the teeth in two dimensions around the remaining arch. This configuration of the remaining teeth allows the principle of indirect retention to be applied for stabilization of the prosthesis.

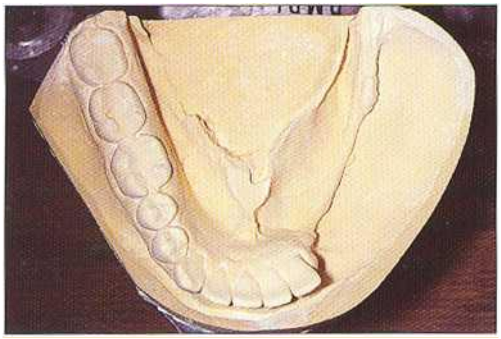


Fig 11-6 While mandibular incisors are rarely ideal abutment teeth, they are frequently the only teeth remaining on the defect side, as seen here. The incisors assume great importance when attempting to stabilize a unilateral prosthesis in a mandibulectomy defect such as this.

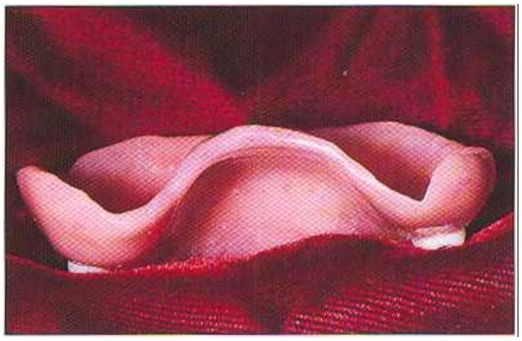


Fig 11 -7 Impingement on the posterior right maxilla by the proximal stump of the resected mandible has limited the extension of the maxillary denture in the critical posterior lateral corner. The resulting underextension in this area results in a maxillary denture that is less retentive and less stable than it could be if full border extension were available.

if possible, to maximize the stability of the prosthesis and to dissipate the functional forces to the greatest number of abutments. Mandibular incisors with adequate root support may serve as abutments, particularly where the canine on the side of the defect has been lost (Fig 11-6). In this situation, the remaining incisors serve to shift the functional fulcrum line from the line of remaining teeth on the nondefect side to a tripod situation where indirect retention can be gained.

The presence of remaining natural teeth in the opposing maxilla is not nearly as important as the number and location of remaining mandibular teeth for predicting postrehabilitation success for the mandibulectomy patient. A complete maxillary denture will usually function quite well against a reconstructed mandibular dentition; exceptions include difficulty in fabrication of a maxillary complete denture where the residual proximal mandibular stump, including the coronoid process, has collapsed against the posterior maxillary alveolus prohibiting adequate denture flange extension necessary lor peripheral seal (Fig 11-7). A complete maxillary denture will also be a problem when a mandibular guide-flange prosthesis is planned to correct mandibular deviation. Pressure from the guide flange will tend to dislodge the maxillary denture.

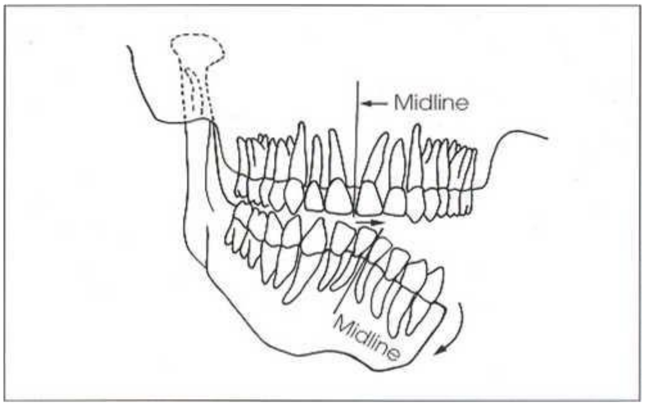


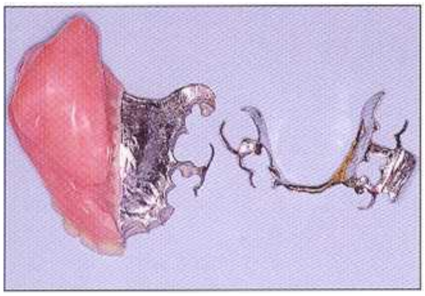
Fig 11-8 Schematic representation of the deviation and rotation frequently seen as a result of mandibular resection. Deviation is caused by loss of tissue volume in the surgical defect. Rotation is caused by gravity and the downward pull of the suprahyoid musculature. (Reprinted with permission from Taylor et al, Chapter 36, in: Thawley et al | eds |, Comprehensive Management of Head and Neck Tumors [ed *2],* © 1999 W. B. Saunders.)

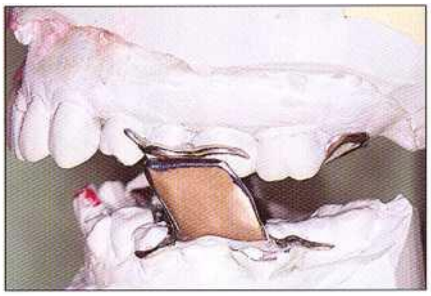
Degree of Postmandibulectomy Rotation and Deviation

Loss of mandibular continuity causes deviation of the remaining mandibular segment(s) toward the defect and rotation of the mandibular occlusal plane interiorly (big 11-8). Mandibular deviation toward the defect side occurs primarily because of the loss of tissue involved in the surgical resection. The need to gain primary closure of the surgical defect requires that the margins of the defect be drawn together, resulting in deviation of the remaining mandible toward the defect. The loss of mandibular continuity allows deviation to occur. A high frequency of radical neck dissection in combination with mandibulectomy further reduces available tissue for wound closure and increases deviation.

Loss of continuity also results in vertical rotation of the residual mandibular segment in an inferior direction. Rotation is caused by two factors. The pull of the suprahyoid musculature on the residual mandibular fragment causes inferior displacement and rotation around the fulcrum of the remaining condyle. The second compounding factor causing mandibular rotation is gravity, fhe loss of anchorage of the elevator muscles and temporomandibular ligament on the defect side allows the mandible to fall vertically away from its normal position. The functional results of deviation and rotation of the mandible are facial disfigurement, loss of occlusal contact between remaining maxillary and mandibular teeth, and, in many cases, loss of the ability to bring the lips together for saliva control and to initiate the swallowing process.

Treatment for mandibular deviation and rotation is best done by restoration of continuity through osseous grafting. When restoration of mandibular continuity is not possible, early postresection physical therapy is indicated to reposition the mandibular fragment toward a more normal position and to minimize the effect of scar formation that will make deviation more severe and less amenable to prosthodontic intervention. The physical therapy should involve having the patient gently push the mandible away from the defect toward a more normal position. While holding the mandible in position, the patient should open the mouth as widely as possible to stretch the musculature and the resection site. Repeated opening and closing while maintaining the mandible in its normal alignment is useful to train the mandible and to prevent or limit the effect of scar formation in the resection site. Stretching exercises are extremely important during the early rehabilitative phase. If physical therapy and reposition training are delayed until after the initial postoperative healing phase of 6 to 8 weeks, it is unlikely that exercise and physical therapy will be beneficial. Reposition training of the resected mandible becomes much less effective as time following surgery increases.





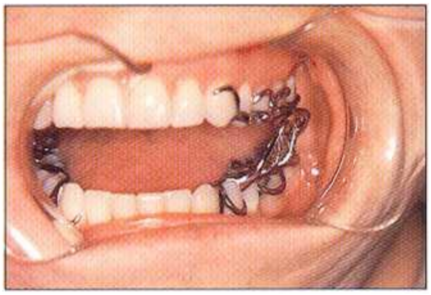


Fig 11 -9a *(left)* Mandibular guide flange used to restrict deviation of the mandible during function. The flange will function against the clasp assembly of the opposing obturator prosthesis, thereby splinting the maxillary teeth against the lateral forces of the flange.

Fig 11-9b *(center)* Mandibular guide flange shown in the open position on the articulator. The flange acts against the clasp assembly of the maxillary obturator, which reduces the lateral forces on the maxillary teeth.

Fig 1 l-9c *(right)* Mandibular guide flange shown intraorally. For this patient, a maxillary removable partial denture framework was fabricated solely to provide a buccal bar for the mandibular flange to function against. Caution should be exercised when fabricating a guide flange without concurrent fabrication of a maxillary framework to resist the pressure of the flange. Without the maxillary splinting bar, the maxillary tooth or teeth that the flange acts against may undergo orthodontic movement and the flange may then cause soft tissue damage adjacent to the teeth.

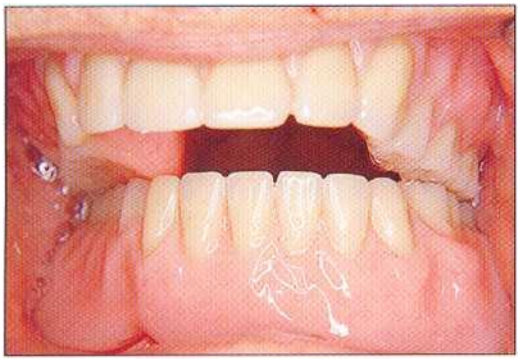


Fig 11 -10 Clinical example of a maxillary guidance ramp fabricated as part of a tooth-supported overdenture and opposed by a mandibular overdenture. For this patient, chewing actually occurred against the ramp, and the ramp caused very little deflection of the mandible toward its original position.

The use of mandibular resection guidance prosthcscs is an option to consider when the residual mandible can be easily repositioned into proper alignment by manual guidance either by the patient or by the clinician. If minimal pressure is required to maintain the mandible in its correct position, a mandibular guide flange and/or a maxillary guidance ramp may be a partial solution to the problem of deviation (Moore and Mitchell, 1976; Martin et al, 1985; Schneider and Taylor, 1986) (Fig 11-9). A mandibular guidance prosthesis is not likely to be successful and may be damaging to the remaining teeth and soft tissues if maintaining the mandible in its correct position requires the application of force beyond that needed to gently assist correct repositioning. If even moderate force is required to maintain mandibular position, the clinician should consider utilizing a maxillary casting that provides a buccal bar for the mandibular guidance prosthesis to slide against. The maxillary casting serves to splint and protect the surfaces of the maxillary teeth against which the guidance prosthesis functions.

A maxillary palatally positioned guidance ramp may be as effective as a guide flange for many patients, particularly when deviation is less severe. The guidance ramp may be incorporated into a palatal-drop prosthesis in cases of partial glossectomy with limited residual tongue mobility. Such a prosthesis serves dual purposes of mandibular guidance and residual tongue articulation. Neither mandibular guidance prostheses nor palatal guidance ramps are indicated for the edentulous patient without the use of dental implants to stabilize the denture(s) (Fig 11-10). Lateral forces generated by the prostheses are not compatible with complete dentures.

Available Mouth Opening

Many patients experience severe limitation of mouth opening after mandibulectomy. This may improve with time as muscle trismus associated with surgical trauma subsides and as scar tissue softens, but frequently the ability to open does not improve sufficiently to allow access for dental care, including the making of impressions. The limitation of opening may in fact become more severe as fibrosis progresses during normal healing. Sufficient mouth opening to allow dental access and the making of impressions is paramount for any prosthodontic rehabilitation. A simple test to determine adequate opening is to attempt to insert a stock mandibular impression tray into the mouth. If this procedure cannot be accom plished, rehabilitation is unlikely to occur.

Postsurgical trismus may be treated effectively if treatment is undertaken soon after surgery. Stretching exercises, moist heat, and analgesics will be beneficial. Exercises may be as simple as placing a finger on the mandibular arch and pulling downward. Various appliances are available commercially or can be custom made for the patient. Instructions for exercises should emphasize frequent assisted stretching for short periods followed by frequent maximum opening using the depressor muscles of the mandible. If severe trismus is not countered with stretching and mobility exercises, the traumatized muscles may fibrose. Stretching exercises should be demon strated to the patient soon after surgery and reinforced on a regular basis. To be of maximum benefit to the patient, exercises must be initiated within 2 weeks, preferably at 1 week, following surgery. Frequent visits with the prosthodontist or with a physical therapist may be necessary to improve compliance and to monitor progress.

Fibrosis creating mature scar tissue is much more difficult to treat and to improve on with stretching exercises. For that reason it is critical to prevent scar formation by early postsurgical exercise intervention whenever possible. Stretching exercises will be of only limited benefit for the patient suffering from severe scarring. Severe fibrosis limiting mouth opening is a life-threatening problem when intubation for general anesthesia is necessary. Tracheostomy may become necessary in such cases. Occasionally, release of scar tissue by forced stretching under general anesthesia is required to obtain sufficient mouth opening for passage of food and to permit dental care. In my experience, forced opening under anesthesia to release scar tissue has been of limited benefit, lasting only a short period of time before limitation of opening returns to prestretching levels. Similarly, stretching exercises have generally been of limited benefit for patients with long-standing limitation of opening. Every effort should be made to treat limitation of opening aggressively at an early stage to prevent permanent, severe scarification.

Functional Limitation of the Tongue

It can be argued that the degree of impairment of normal tongue function is a more important factor in determining the prognosis of mandibulectomy rehabilitation than the presence or absence of teeth to serve as abutments. This may well be the case. Frequently, the surgical wound is closed by suturing the remaining tissues of the floor of the mouth or the tongue to the remaining buccal tissues. This method of wound closure severely limits the mobility of the oral tongue depending upon the size and location of the defect. Limitation of normal tongue mobility will seri-

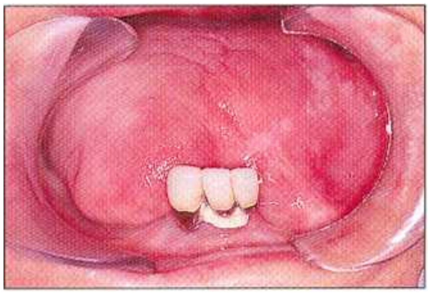


Fig 11 -11 Situation in which a floor-of-mouth resection was closed primarily by suturing the undersurface of the tongue to the buccal mucosa. It is likely that sufficient residual tongue remains to allow normal function if the tongue can be surgically released by mucosal or skin grafting. Without surgical release there is little that prosthodontic intervention can accomplish.

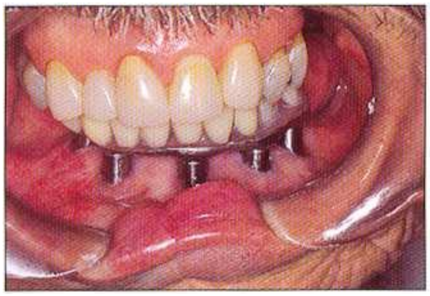
ously compromise speech, swallowing, mastication and control of' a food bolus, and ability to control a removable prosthesis. Severely limited tongue mobility as a prognostic factor for rehabilitative success frequently dictates surgical revision of the mouth floor to restore tongue mobility. Fortunately, soft tissue procedures involving lingual vestibuloplasty and skin or mucosal grafting arc usually effective in attaining the goal of increased tongue mobility. Even when a portion of the oral tongue has been resected, compromised function can be improved substantially if mobility[7] is maintained or secondarily recreated through vestibuloplasty. The clinician must determine whether lack of tongue mobility is due to tethering or the result of resection of a significant portion of the tongue itself (Fig 11-11). Tethering can be addressed by surgical release of the tongue; loss of substantial tongue volume is less likely to be improved significantly by vestibuloplasty.

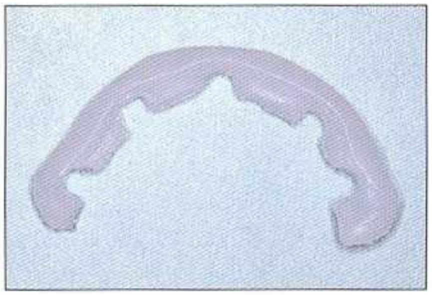
Evaluation of tongue mobility can be done easily by asking the patient to extend the tongue into each cheek and to lick the lips. If these functions can be performed, mobility is probably adequate for control of a prosthesis and food bolus. If the patient is unable to perform these motions, the prognosis for satisfactory rehabilitation, particularly with a removable prosthesis, is greatly diminished and surgical release of the tongue is indicated. For the patient whose resection involved the anterior mandible, the ability to lick the lips without a prosthesis in the mouth may become difficult or impossible when artificial teeth are in place. In such cases consideration may be given to lowering the anterior occlusal plane to allow the tongue a more direct path to the lips. Another possibility is to set the denture teeth more lingually than would normally be the case, supporting the lips less and thereby bringing them closer to the tongue.

If speech is not satisfactory prior to rehabilitation, the mandibulectomy patient should be referred for speech therapy because speech improvement is not likely to occur as a result of prosthodontic intervention in the mandible. An exception is the situation where partial or total glossectomy has been performed. In that situation, a palatal-drop prosthesis or glossectomy prosthesis may be effective. These prostheses are described in detail in Chapter 14.

Loss of sensory innervation will severely compromise tongue function and the prognosis of prosthodontic rehabilitation. When the lingual nerve (trigcminal/fifth cranial nerve) is sacrificed during resection, the tongue on the defect side will permanently remain without feeling. Loss of sensory capability will preclude effective speech, mastication, and prosthesis control on the side of the defect. In this situation, one must anticipate that any prosthesis placed on the defect side will serve only for cosmetic replacement of missing teeth and contiguous structures, to support normal facial contour, and, possibly, to prevent supraeruption of opposing natural teeth or to assist in stabilizing an opposing complete denture. The patient must understand that mastication on the side with tongue anesthesia is very unlikely.

I .oss of sensory innervation of the buccal mucosa (long buccal nerve) and the lower lip (mental nerve) will reduce the patient’s ability to control food and saliva but by themselves are not as debilitating as loss of lingual sensory innervation.





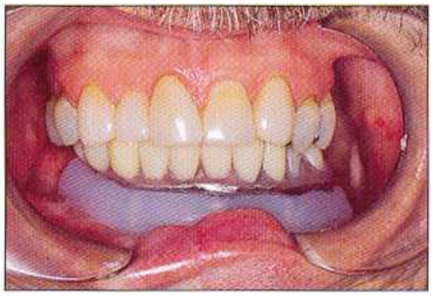


Fig 11-12a *(left)* Patient who had an anterior mandibulectomy reconstructed surgically with bone graft and dental implants. While the fixed-detachable prosthesis appears to be quite normal in design, the patient was unable to control food and saliva due to limited tongue control and loss of sensory innervation of the lower lip. The patient's primary concern was constant drooling.

Fig 11-12b (*center*) A silicone dam or barrier was fabricated to fit beneath the mandibular prosthesis to prevent saliva and food from escaping by this route.

Fig 11-12c *(right)* Silicone dam in place. The dam was of limited benefit for the patient in his ability to control saliva and limit drooling. It had no beneficial effect in controlling a food bolus.

Loss of motor innervation of the tongue is encountered less frequently than sensory innervation because the hypoglossal (12th cranial) nerve lies deep in the floor of the mouth at the base of the tongue and is less frequently involved in floor-of-mouth/mandibulectomy resection. Loss of motor innervation of the tongue occurs more frequently as a result of glossectomy and, unlike mandibulectomy, is usually more debilitating the farther posterior the site of resection. This is due to the increased likelihood of loss of motor and sensory innervation in situations involving posterior floor-of-mouth or base-of-tongue resections. It is important to recognize that anterior mandibular resection in the symphyseal region is, in general, more debilitating than posterior mandibular resection, but posterior resection of the tongue is much more debilitating than anterior tongue resection (assuming the anterior resection does not result in tethering of the tongue due to surgical flap closure). These general observations are the result of involvement of critical anatomic structures lost through two different surgical procedures. When motor innervation of the tongue is sacrificed, the prognosis for improved function with prosthodontic rehabilitation of the alveolus and teeth is very guarded. Similarly, loss of motor innervation of the cheek and lower lip (facial/seventh cranial nerve) will compromise a patient’s ability to control saliva and a food bolus. At times, loss of salivary control becomes paramount to a patient’s needs. Various attempts to control or channel saliva away from the lips have met with some but usually limited success (Fig 11-12). Motor control of the muscles of the lower face is an important factor to consider when determining prognosis for mandibulectomy rehabilitation.

Compromise of Vestibular Extensions

A frequently occurring problem resulting from mandibulectomy, related to problems described in the previous section dealing with tongue mobility, is the loss of normal vestibular anatomy following ablative surgery involving the mandible. Normal vestibular anatomy is important in prosthodontics to allow extension of prosthesis flanges for maximal support, stability, and peripheral seal associated with retention. Loss of the vestibule following surgical resection may dramatically affect the prognosis of tissue-supported removable prostheses because of the loss of normal border extensions. Even when mandibular

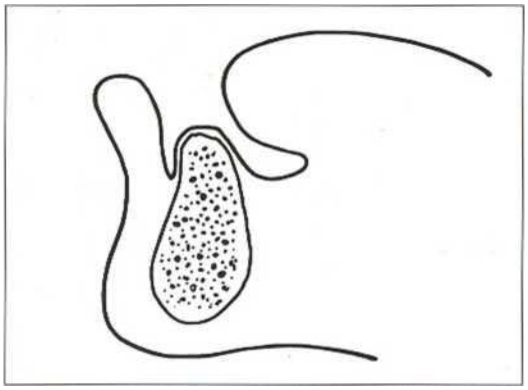


Fig 11-13a Schematic representation of a cross section of the mandible through the midline in a normal situation. Labial and lingual vestibules are present and the residual alveolar process presents a positive profile.

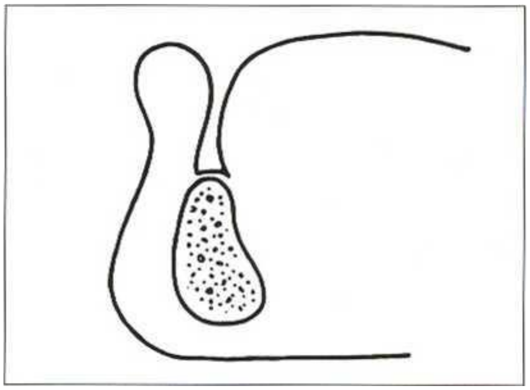


Fig 11-13b Schematic representation of a midline cross section through a mandible that has been reconstructed by a bone graft without subsequent soft tissue vestibuloplasty to recreate the labial and lingual sulci.

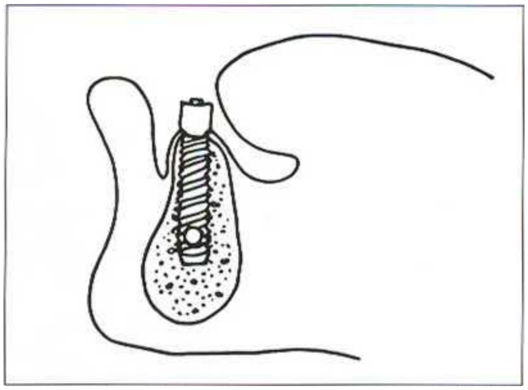


Fig 11-13c An implant placed in the normal mandible does not impinge on the lingual or labial soft tissues.

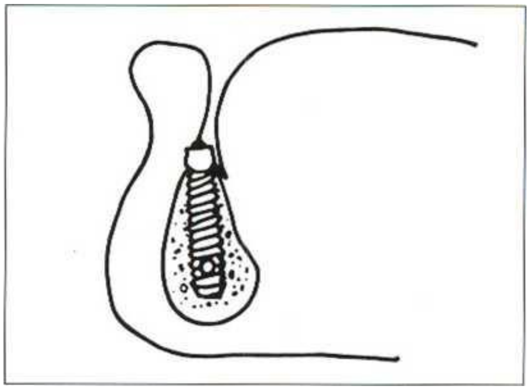
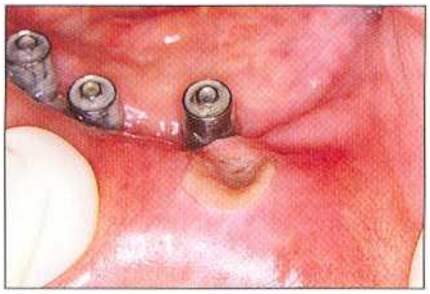
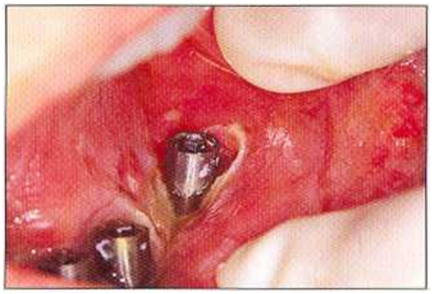


Fig 11-13d An implant placed into a reconstructed mandible may create a situation following abutment connection in which the abutment presses against the inside of the lower lip.





Figs 1 l-14a and 11 -14b Two examples of a situation in which the placement of an abutment at second-stage surgery has created a severe ulceration of the lip adjacent to the abutment.

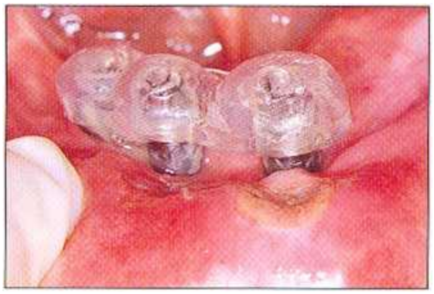


Fig 11-15 A soft mouthguard-material protective cap has been fabricated to prevent the sharp edge of the abutments from cutting into the lip. This problem usually disappears following prosthesis placement, although the patient's ability to clean around the implant abutments may be very limited.

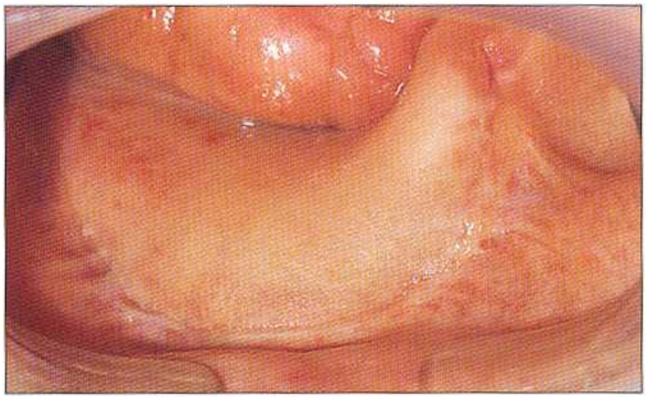


Fig 11-16 The use of skin grafts, either as liner for vestibuloplasty or as part of flap reconstruction as seen here, is very common. The skin graft makes an excellent base for support of a removable prosthesis when used as a vestibuloplasty graft, particularly when it is placed directly on periosteum and is tightly bound down.

continuity has not been sacrificed or when continuity has been restored by bone grafting, prognosis of prosthodontic rehabilitation is closely dependent upon adequate vestibular extension. The prosthodontist should not hesitate to refer a patient for surgical revision of compromised soft tissue anatomy. Such referrals will frequently make the difference between success and failure.

In situations where mandibular continuity has been restored with bone grafting and implants are considered part of the rehabilitation, soft tissue anatomy is again a eritical prognostic indicator that must be evaluated and treated in a somewhat aggressive manner. In situations with normal anatomy, implants are routinely placed into the crest of the residual alveolus and bordered by normal vestibular anatomy. This is not the case with the bone-grafted mandible or for the patient with a marginal alveolar resection without loss of mandibular continuity. In these .situations, it is common to find the crest of the residual mandible or the bone graft at the base of a V-shaped sulcus between the surgically altered buccal soft tissues and the floor of the mouth or residual tongue (Fig 11-13). Implants placed into this environment will present problems with soft tissue management that frequently result in chronic inflammation of the peri-implant soft tissues after the abutments are connected. At times this irritation can cause severe infection in adjacent tissues (Fig 11-14). Provisional protective covers fabricated to fit over the abutments may alleviate the problem during the treatment phase by protecting the soft tissues from the sharp edges of the implant abutment (Fig 1115). This situation may improve when the prosthesis is completed or may continue to be an ongoing problem, particularly with overdenture prosthc- ses that allow tissues to collapse onto the bar or ball anchor substructures when the denture is not in place. Implants situated in this V-shaped sulcus may also be difficult or impossible for the patient to access for hygiene procedures, further compounding the soft tissue problems. Surgical recreation of vestibular depth both buccally and lin- guallv should be considered in many of these situations.

Skin Grafting

Surgical reconstruction following mandibulec- tomv frequently involves the use of skin grafts either as lining for the surface of resected soft tissue or as part of skin and connective tissue grafts including pedicle flaps, free flaps, or vascularized bone and soft tissue grafts (Fig 11-16).

Skin as an oral graft material has several distinct advantages and disadvantages that must be considered by the clinician when planning prosthodontic rehabilitation treatment following mandibulectomy. Though skin is an effective load-bearing tissue, particularly when compared to nonkeratinized oral mucosa, transplanted tissue does not have sensory innervation and can be susceptible to trauma from ill-fitting or over loaded prostheses. Fortunately, skin is a relatively resistant tissue that can withstand pressure and chafing from a prosthesis quite well. Rapid turnover of keratin-producing cells in the skin graft give added protection to underlying bone and connective tissue.

When full-thickness grafting has been performed, the skin will continue to grow hair, which may be an annoying problem for the patient. If skin grafting is planned without additional connective tissue grafting, every effort should be made to utilize split-thickness grafts, thereby avoiding incorporation of hair follicles into the graft.

Dental implants used in sites with grafted skin may also create severe problems. Skin, particularly in the oral environment, does not tolerate the titanium surface of implant abutments, and the reaction may be quite severe. Mitchell and coworkers (1990) first described this phenomenon and recommended custom-fabricated gold alloy components to solve chronic irritation problems seen when titanium penetrates the skin graft.

Radiation Therapy

Rehabilitation of the patient who has undergone mandibulectomy is frequently complicated by a history of therapeutic radiation as part of the treatment given for malignancy. For the purpose of discussion in this chapter, a history of radiation therapy or anticipated radiation therapy directly impacts treatment planning and prognosis in a major way. Tissues that have been radiated are fragile, sensitive to manipulation, desiccated, slow to heal, prone to infection, and at risk for osteoradionecrosis, particularly in the mandible. Reconstructive surgical procedures to improve the prognosis for prosthodontic therapy must be weighed against the increased risk of complication associated with those procedures caused by the history of radiation. Placement of soft tissue-supported prostheses carries with it increased risk of complication as well. Management of the postradiation patient is treated in detail in Chapter 3 and the use of dental implants in the radiated mandible is discussed in Chapter 13.

Previous Experience with Removable Prostheses

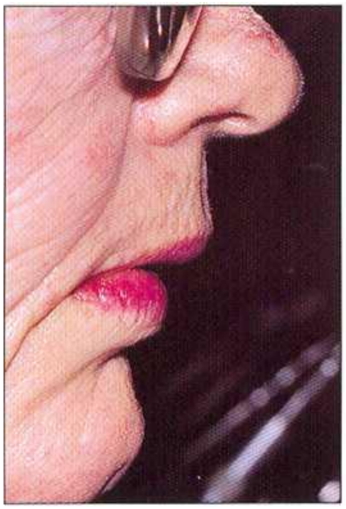
A patient's prior experience with removable prosthescs may be an indicator of how successful rehabilitation will be, particularly for the edentulous patient. The patient who was previously dentate or partially dentate and as part of treatment for malignancy is rendered edentulous in the mandible presents an extremely challenging situation to the clinician. A mandibular denture is difficult for many patients to adapt to, but when that adaptation is compromised by the effects of cancer surgery, it may become impossible.

A worst-case situation occurs when a patient with remaining healthy maxillary teeth is rendered edentulous in the mandible by treatment for malignancy. The situation in which a patient retains maxillary teeth but has lost all mandibular teeth is an extremely difficult one to treat in any case, but it is nearly impossible to address in the mandibulectomy patient. The loss of the mandibular dentition as a result of cancer therapy is cause for seriously considering extraction of the remaining maxillary teeth as well, no matter what their state of health. There is no more difficult problem in prosthodontics than to make a patient understand the need to remove healthy remaining maxillary teeth as part of the treatment for lost mandibular teeth. Fortunately, the option of implant rehabilitation of the mandible in such situations has made this problem somewhat less difficult to deal with.

Altered Anatomic Relationships Following Restoration of Mandibular Continuity

Restoration of mandibular continuity is of primary importance in determining the prognosis of postmandibulcctomy rehabilitation. Unfortunately, restoration of continuity frequently creates new problems to be dealt with prosthodontically.

One of the most difficult situations faced postsurgically is seen in the patient whose resection



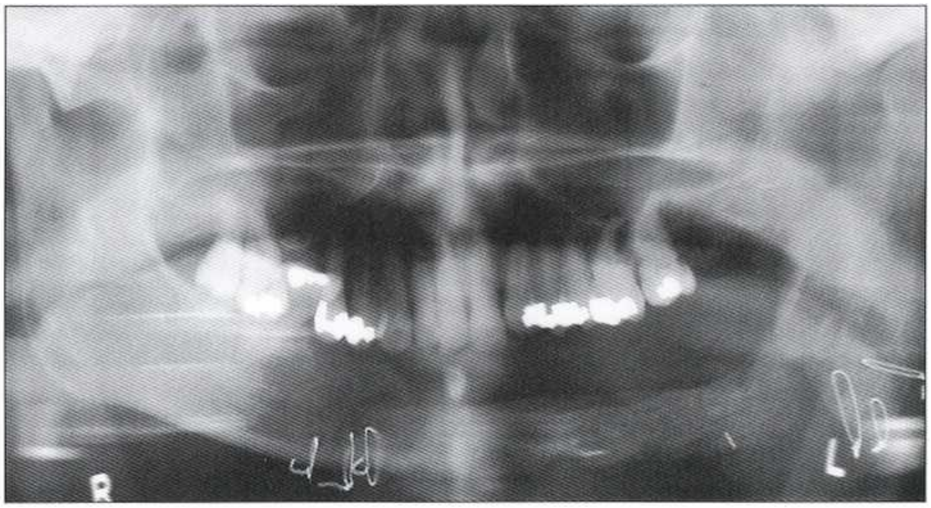


Fig 11-17 *(left)* Profile of a patient who has undergone anterior mandibular resection and reconstruction with a bone graft from the iliac crest. The lower face exhibits esthetic deficiency. It may not be possible to restore the mandibular teeth to their presurgical relationship with the maxillary anterior teeth.

Fig 11-18 *(right)* Panoramic radiograph of a patient who has undergone resection and reconstruction of the mandible from left mandibular angle to the right premolar area. While the bone graft appears to be well positioned, the right mandibular fragment is positioned far to the lingual of its original position and the mandibular molars occlude with the palatal mucosa.

involved the anterior mandible and subsequent surgical reconstruction by bone grafting. Grafting the anterior mandible frequently results in a graft that is deficient anteriorly (Fig 11-17). This severe horizontal deficiency results from the difficulty seen surgically when attempting to restore normal anatomy in an area with inadequate remaining soft tissue and the necessity for tight soft tissue closure over the grafted bone. The clinical result is one in which the maxillomandibular relationship is severely Class II and with reduced likelihood of completely satisfactory prosthodontic rehabilitation. The prostho- donfic difficulties seen in rehabilitating a patient with this type of defect are numerous and include an inability' to provide adequate lower lip support for esthetics, speech problems associated with mandibular dentition placed too far linguallv to allow normal articulation, inability' to control a food bolus due to lack of motor function of the lip and muscles of the lower face, excessive display of mandibular teeth due to the patient’s inability to maintain normal lower lip posture, and difficulty gaining adequate space for prosthesis placement without encroaching on the function of the tongue.

An additional problem occasionally seen following anterior bone grafting is a misalignment of the remaining unresected mandibular fragments and resultant relationships between mandibular and maxillary teeth. Such misalignment is variable in relation to the maxilla and the degree of difficulty' encountered during prosthodontic rehabilitation (Fig 11-18).

Reconstruction of posterior defects with bone grafts is somewhat more predictable from the standpoint of prosthodontic rehabilitation than anterior defects, but problems associated with size and positioning of the bone graft may still cause difficulties. The mediolateral position of the graft is frequently seen to be lateral to the original position of the mandibular body. This results in a prosthesis that must be built in crossbite to maintain the denture teeth over the supporting base of the bone graft. When implants are utilized, the implants require extremely angled

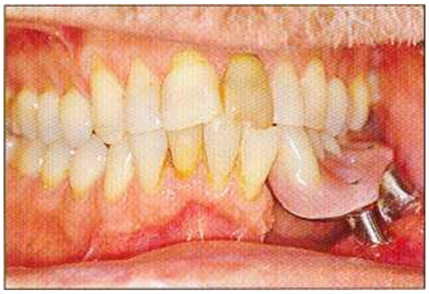


Fig 11 -19 Severe tilting of dental implants placed into a bone graft that was buccal to the position of the mandible before tumor surgery. The prosthesis is cantilevered far to the lingual to achieve tooth contact with the opposing maxillary dentition. This arrangement obviously creates mechanical problems with the long-term stability of the prosthesis and supporting implants.

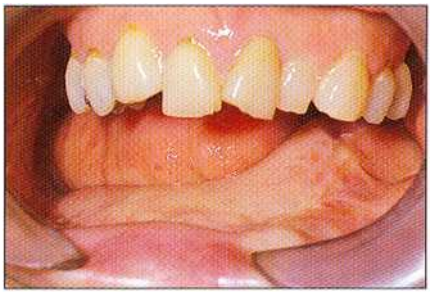


Fig 11-20 Patient following reconstructive surgery of the mandible in which insufficient space exists on the patient's left side to permit placement of a prosthesis or implants.

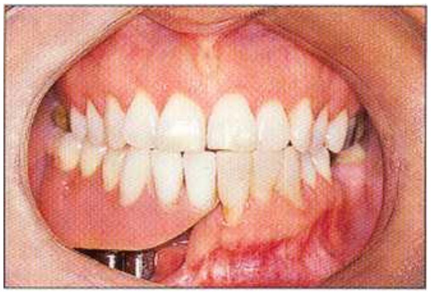


Fig 11-21 Patient following surgical and prosthodontic rehabilitation after hemi-mandibulectomy. The distance between the bone graft and the opposing teeth on the patient's right side puts the implants and the prosthesis they support at increased risk of failure because of the long lever arm of the prosthesis above the bone level.

placement, and the prosthesis they support may have to be cantilevered further to the lingual to permit tooth contact (Fig 11-19).

The surgically reconstructed mandible frequently presents a situation in which the interarch space between the bone graft and the opposing maxilla is either greatly diminished or greatly exaggerated. It is my experience that a surgical result with excessive interarch distance is the most common outcome of the two.

inadequate interarch distance limits prosthodontic rehabilitation due to a lack of space in which to place a prosthesis and, if severe enough, may even preclude implant placement (Fig 11 20). A lack of interarch space may be the result of bone-graft position or it may be the result of excessively thick soft tissue flap reconstruction in the resected area. Lack of space may be addressed by increasing the vertical dimension of occlusion within physiologic limits or may require surgical revision of hard and soft tissues to allow adequate interarch space for implant and/or prosthesis placement.

It is more common to encounter a situation where the mandibular graft is situated a great distance from the opposing arch (Fig 11-21). This presents problems in attempting to control forces on the remaining abutment teeth or on implants placed into the graft. A soft tissue and tooth-supported prosthesis with a large vertical discrepancy between the remaining natural abutment teeth and the level of the soft tissue-supported denture base of the prosthesis is likely to generate severe torsional forces on the natural teeth. In such situations, the design of the framework for the prosthesis should allow for maximum use of all remaining teeth as well as maximum soft tissue support beneath the denture base. Unfortunately, one frequently finds a situation where insufficient numbers of healthy abutment teeth are present and the dependence upon soft tissue support becomes even more critical. To compound this problem, the soft tissue base overlying a mandibular bone graft is rarely adequate support for a denture base. Lack of vestibular depth and attached mucosa limit the ability to gain soft tissue support.

When implant rehabilitation of the bone-grafted mandible is undertaken, the problem of excessive interarch- distance is often a difficult problem to manage. Frequently the volume of grafted bone available for implant placement is limited, and as a result the length, diameter, and number of implants that can be placed to support

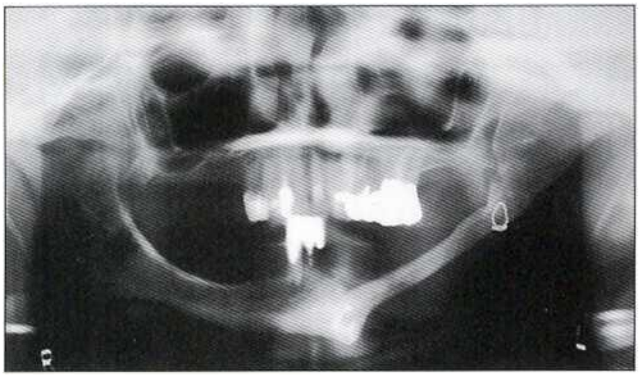


Fig 11 -22 Panoramic radiograph illustrating inadequate bone for implant placement. Surgical reconstruction in this case was with a tree-rib graft.

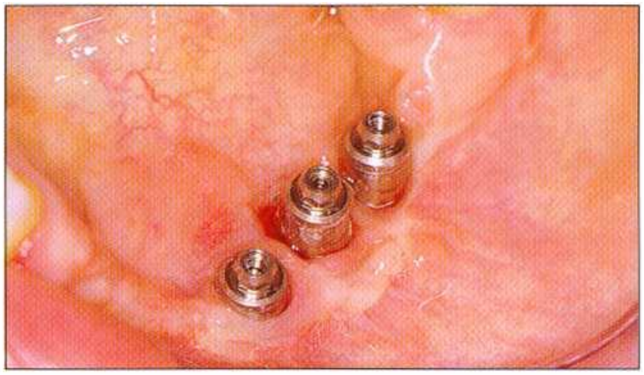


Fig 11-23 Linear placement of three implants in a previously placed mandibular bone graft. The graft was thin buccolin- gually, thereby precluding placement of the implants in a more desirable tripod arrangement.

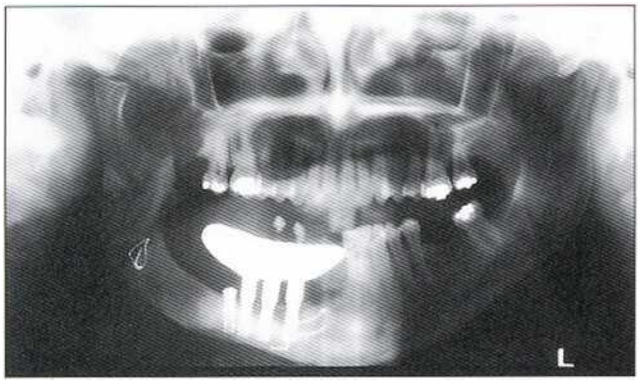


Fig 11 -24a Panoramic radiograph of a patient following re-habilitation that included iliac crest bone grafting and implant placement. Note apparent superimposition of anterior implant and surgical stainless steel wire used to anchor the bone graft.

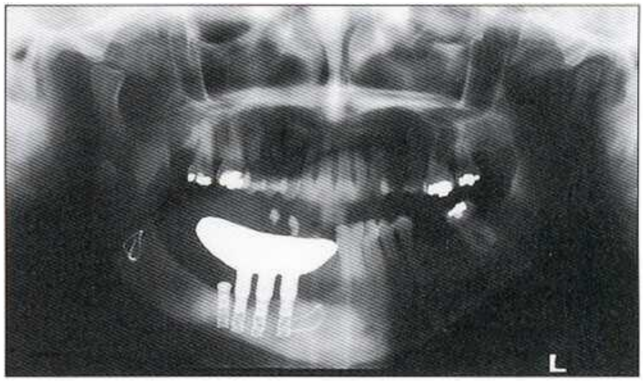


Fig 1 l-24b Panoramic radiograph taken at 1-year follow-up. Note that part of the wire is absent. No surgery was performed between the times the two radiographs were taken. One possible explanation is that the steel wire has partially dissolved due to corrosion caused by contact or close proximity to the titanium implant. Bone loss around the implant ultimately resulted in its loss.

a prosthesis are less than ideal (Fig 11-22). The placement of sufficient numbers of implants to support prostheses that span long vertical lever arms is complicated by inadequate bone to accommodate them. The practice of placing three or more implants in an offset or tripod configuration to stabilize the prosthesis and to minimize bending moments on the implant pillars is frequently not possible because of a lack of width of the bone graft (Fig 11-23). Without an offset or so-called tripodized arrangement of supporting implants, the risk of failure appears to increase substantially.

Foreign bodies such as bone plates and screws or wires in planned implant sites may require removal in preparation for implant placement or simultaneous with implant placement. If metallic foreign bodies are left in contact with or in close proximity with endosseous implants, the potential for corrosion cannot be ignored (Fig 11-24).

Conclusion

Surgical and prosthodontic rehabilitation of the mandibulectomy patient has the potential of being extremely gratifying to the clinician as well as making an enormous impact on the quality of life for the patient. At the same time, the complexities of dealing with the many factors involved in successful diagnosis and treatment planning of the patient with a mandibular defect make the final outcome of treatment difficult to predict and often less than completely satisfactory. The introduction of predictable endosseous implants as adjuncts to traditional surgical and prosthodontic methods of treating such patients has changed the way their treatment is planned and executed. It is hoped that future developments will continue to improve outcomes of postmandibulectomy treatment to further improve the quality of life for patients requiring such treatment.

References

Curtis T, Cantor R. The forgotten patient in maxillofacial prosthetics. J Prosthet Dent 1974; 31:662.

Martin J, Shape R, Jacob R, King G. Mandibulectomy positioning prosthesis for the partially resected mandibulcctomy patient. J Prosthet Dent 1985;53:678.

Marunick M, Roumanas E. Functional criteria for mandibular implant placement post resection and reconstruction for cancer. J Prosthet Dent 1999;82:107.

Mitchell D, Synnott S, VanDercreek J. Tissue reaction involving an intraoral skin graft and CP titanium abutments: A clinical report. Int J Oral Maxillofac Implants 1990;5:79.

Moore D, Mitchell D. Rehabilitating dentulous hemimandibulectomv patients. J Prosthet Dent 1976;35:202.

Schneider R, Taylor T. Mandibular resection guidance prosthescs: A literature review. J Prosthet Dent 1986;55:84.

Prosthodontic Rehabilitation of the Mandibulectomy Patient

o Rhonda F. Jacob, DDS, MS

The mandible is a single bone that creates the peripheral boundaries of the floor of the oral cavity. Muscles of mastication are bilaterally attached to the mandible to generate a variety of complex mandibular movements useful in speech, swallowing, mastication, and respiration. The mandible and the muscles of mastication also give form to the lower third of the face. Disruption of the mandible has the potential to disrupt any of these functions. Rehabilitation of the mandibulectomy patient should always consider form and function. The mandible cannot be separated from its contiguous structures when considering its contribution to mastication, swallowing, or speech. Resections of the mandible may cause topographic defects while maintaining continuity, but facial form and movements of the mandible can often be preserved. Discontinuity defects of the main body of the mandible cause deficits in facial form. They also affect mandibular movement consistent with the loss of muscle attachments and unilateral preservation of contralateral muscle attachments. This chapter will describe prosthodontic methods to restore common defects of the mandible that result from cancer resection. Similar mandibular defects can result from trauma, and the prosthetic techniques used to rehabilitate them are similar to those presented here.

Mandibular Resections: Surgical Considerations

Marginal Mandibulectomies

Marginal mandibulectomies involve resections of the mandibular body with overlying soft tissues while maintaining the inferior cortex of the mandible and its continuity. Tumors necessitating a marginal mandibulectomy are usually located in the gingival tissues or the floor of the mouth. The resection can extend from the retromolar trigone to the contralateral retromolar trigone area or terminate anywhere in between. A coronal cut of the alveolar process below the level of the root apices is the most common bony resection, but occasionally a second frontal cut will resect the lingual cortex. The muscles of mastication are usually intact, so mandibular movement is not disrupted.

Soft tissues arc used to reconstruct marginal mandibulectomies. Whether the reconstruction is a skin graft, local flap, pedicle flap, or microvas- cular free flap (MYTT) depends on the extent of the resection of associated oral tissues. Skin grafts are thin and avascular but can be placed over cut medullary bone. After healing, skin grafts are

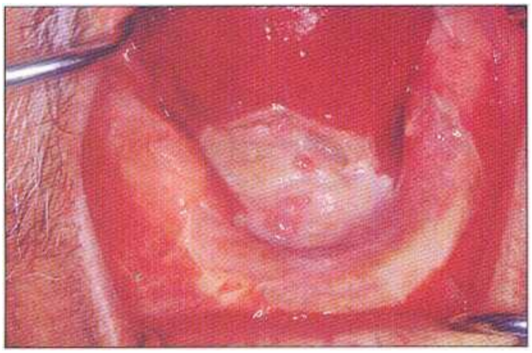


Fig 12-1 Skin grafts placed over marginal mandibulectomies heal uneventfully even with irradiation and are sound prosthesis-bearing areas.

bound to the mandible (similar to attached gingival tissues), are not compressible, and do not move over the mandible. They serve as excellent prosthesis-bearing surfaces (big 12-1). Local and pedicle flaps are bulky in comparison, often tether adjacent structures (primarily the tongue), and are displaceable and mobile. They are poor prosthesis-bearing surfaces due to their bulk and may impinge upon space needed for dentition. These flaps are often sutured to associated structures such as the lips, cheeks, and tongue. When these structures move, the Hap also moves and unseats the prosthesis.

I ,ocal and pedicle flaps are used less frequently for reconstruction than in the past. The tethering of residual tissues is a functional deficit that can be overcome by use of MVFFs. Free flaps are ideal when associated structures in addition to the mandible have been resected. These flaps offer volume to restore the bulk needed for the associated soft tissue resection and can be quite pliable so as not to tether residual tongue function. Because these tissues are vascularized by anastomoses to nearby blood vessels in the head and neck, they are ideal for reconstruction in previously irradiated tissue beds or to cover a previously irradiated mandible. Despite the advantages of MVFFs, when these tissues cover the mandible they are compressible and mobile and create an unstable prosthesis-bearing surface. Whenever soft tissue bulk is not required, or when the recipient bed has not been previously irradiated, a skin-graft reconstruction should be considered because of the prosthetic advantages.

Discontinuity Mandibulectomies

Discontinuity mandibular resections require resection through the entire mandible and may involve any part of the mandible from condyle to condyle. Tumors requiring discontinuity resections may be primary tumors of the mandible but more frequently arise in tissues of the oral cavity with contiguous spread into the mandible. Because the primary tumors often arise in contiguous structures, soft tissues of the oral cavity are also resected. These soft tissue primaries may include the soft palate, tonsil, tongue, floor of the mouth, or buccal mucosa/cheek. When the primary tumors are laterally located within the oral cavity or oropharynx, the mandibular resection will be unilateral. When oral cavity lesions are in the midline of the floor of the mouth, the mandi bular resection will involve the symphyseal area.

Reconstruction of discontinuity defects has been revolutionized by the MVFF. Local soft tissue and pedicle soft tissue flaps were the mainstay prior to the free flap. Previous soft tissue local flaps involved rotating the residual tongue to the border of the defect for primary closure. The tongue became severely tethered, causing speech and swallowing deficits. The primary soft tissue pedicle flap was the pectoralis muscle rotated on a vascular pedicle from the chest, tunneled under the skin of the neck, and positioned into the oral cavity. This flap tended to limit head movement and had potential to increase mandibular deviation toward the surgery side due to tethering of the residual mandible. Prior to MVFFs, the bone- graft alternatives were nonvascularized particulate bone grafts or nonvascularized bone segments.

These grafts had poor success rates when the oral cavity and extraoral tissues were confluent; therefore, immediate bone reconstructions were rarely undertaken. Radiation to the recipient tissue beds frequently precluded delayed particulate bone grafts. The MVFF has made it possible to immediately reconstruct the mandible with microvas- cularized bone and soft tissue despite a surgical defect that communicates through the cxtraoral skin and the oral cavity. This flap can also survive in irradiated tissue beds. The two primary sources of microvascularizcd bone for mandibular reconstruction are the fibula and iliac crest. The fibula is the most common choice due to the decreased morbidity at the donor site, the great length of bone that is possible, and the opportunity to employ a two-team intraoperative approach.

Not all mandibular defects are reconstructed with bone. When posterior lateral defects are present, soft tissue MVFFs can be used to mitigate the morbidity of bone loss at the donor site. The most common of these flaps for intraoral use are from the forearm or the rectus muscle. At times soft tissue local and pedicle flaps are still employed: when atherosclerotic vessels are present or when other patient health factors preclude lengthy microvascular surgery. Practitioners still encounter prosthetic patients who were treated before the benefit of MVFFs. Flic disadvantage of primary soft tissue reconstruction of mandibular detects is the accompanying deviation of the mandible resulting in inconsistent occlusal contacts and accompanying minor to major facial deformities.

Mandibular Deviation: Unilateral Resection

Deviation can be seen in various degrees depending on the extent of mandibular resection. If there is a unilateral resection of the ramus that extends to the angle of the mandible, the pterygoid and temporalis muscle attachments are lost unilaterally Deviation is likely to be observed but will probably be minimal due to bilateral maintenance of the masseter muscles. Such a patient may be able to return to appropriate intercuspation. If the ramus is maintained as a separate bony segment, proximal to the bone resection, the ramus will become malpositioned due to its temporalis and lateral pterygoid attachments. It will be pulled superiorly by the temporalis muscle and medially against the maxilla by the pterygoid muscle. This position obliterates the maxillary buccal vestibule and hinders making a maxillary prosthesis and performing hygiene on the maxillary posterior dentition. In the past, bony reconstruction was not routinely contemplated and the ipsilatcral ramus was resected to prevent this positional problem. When delayed reconstructions arc planned, internal fixation plates or external fixation devices should be used to span the bony resection and maintain the bone segments in their preoperative position.

Rotation of the mandible occurs with unilateral resection. This is most noticeable in the anterior mandible, observed as an inferior rotation with anterior disclusion. This rotation is observed posteriorly as a movement of the mandibular posterior contacts from the buccal cusp tips to the buccal inclines of the buccal cusps.

The amount of deviation and rotation can be somewhat predicted by the amount of unilateral mandible resected. A general axiom is that a greater resection usually equates to more deviation, but this statement is not true for all patients. It is difficult to determine the contribution of the soft tissue surgical reconstruction and ancillary therapies, especially radiotherapy, on the malposition of the mandible. Radiotherapy causes fibrosis of tissues. Depending on the surgical reconstruction, tethering of the residual mandible and associated tissues may occur; this does not allow the mandible to return to its normal position.

When the resection is in the body of the mandible and creates two large independent segments of mandible, the two segments will act independently of each other, influenced by their remaining muscle attachments. If the resection splits the mandible near the midline, the two segments collapse toward the middle of the mouth. Both segments deviate medially and rotate inferi- orly. No coordinated movements occur and the patient cannot concentrate on either side of the mandible to effect a repeatable occlusion. The mandibular segments are constantly changing position during the opening and closing of the mandible. Due to this constant change in position, an intraoral prosthesis cannot be fabricated to unite the two segments. The dentition would have severe orthodontic forces placed upon it and a mandibular denture would unseat. With soft tissue reconstruction, patients have poor function in speech and swallowing and no hope of mastication. These midline resection patients require bony reconstruction.

Mandibular Malposition After Bony Reconstruction

Despite bony reconstruction, the ideal arch form is frequently not obtained. There are technical, anatomic, and patient factors that affect bone- graft position. Some of these can be overcome with modifications in the prosthetic intervention.

Patients may present after bony reconstruction with residual deviation and rotation to the surgical side. This can occur in an immediate reconstruction for two reasons. First, there is minimal proximal mandible on the surgery side to attach the bone graft, and/or second, the mandibular segments are not stabilized and maintained in their preoperative relation to each other during the grafting procedure. In the first case, a functional ramus on the ipsilateral side is the key to success in achieving appropriate mandibular function. Even a mandibular resection from angle to angle that maintains some attachment of the medial pterygoid, temporalis, and lateral pterygoid muscles on the residual rami can achieve normal postoperative mandibular position. A unilateral resection that maintains the ramus can also achieve normal mandibular position. As more of the ramus is resected, however, the attachments of the lateral pterygoid and temporalis muscles exert less influence on mandibular movement. If only the condyle remains on the surgical side, no influential function of these muscles will occur. It is common to see on postoperative radiographs, that the head of the grafted condyle has been pulled from the glenoid fossa (Fig 12-2). Despite the lateral pterygoid attachment, the contralateral masticatorv muscles and the force of facial tissues on the mandible and graft overcome the influence of the lateral pterygoid muscle. When only a small remnant of condyle remains, some surgeons do not attempt to fix the graft to the condyle because of limited surgical access. The graft is left just short of the glenoid fossa. There appears to be little difference in function.

It is also paramount that the two segments of the residual mandible be maintained in their preoperative position relative to each other. The easiest way to maintain the segments is to bend a metal reconstruction plate intraoperativcly to follow the contours of the mandible and to span the resected mandibular section. This plate is screwed to the mandible, then removed, and the bone is resected. The plate is repositioned in the same screw holes for placement of the bone graft. If the surgeon attempts to determine the position of the mandibular segments without a customized, rigid, preresection template, the repositioning of the mandibular segments is only an estimate. These surgical estimates can cause a number of malpositoncd results. The mandible may abut the maxilla laterally or abut the alveolar process at rest. Both of these positions preclude making any oral prosthesis. The patient may have limited range of mandibular motion or pain in the temporomandibular area due to malposition of the condylar segments. The more mandibular bone that remains proximal to the surgical resection, the more accurate one must be in maintaining the presurgical position of the mandible. Some patients have required additional surgical procedures to correct these malpositions because prostheses are usually not successful in alleviating the discomfort.

Evidence of postoperative deviation occurs in delayed surgical reconstructions because delayed reconstructions are often not planned at the time of initial surgical resection. With the advent of osseous MVFF for defects in previously irradiated tissue beds, patients who were previously reconstructed with soft tissue are now returning to their physicians and requesting bony reconstruction. In these situations, the ipsilateral ramus has often been resected and patients have considerable fibrosis and collapse of facial form that may have been persistent for many years. Any ipsilat-

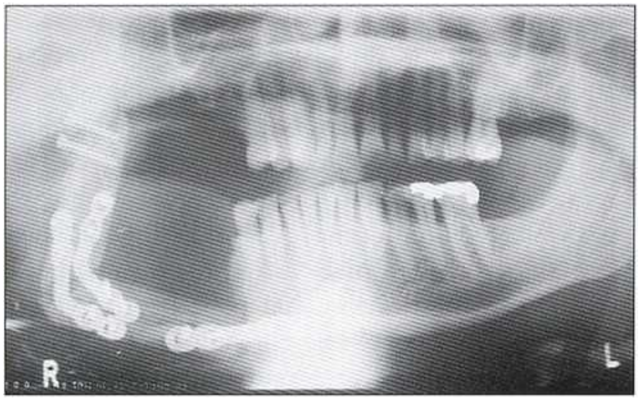


Fig 12-2 This patient had a mandibular reconstruction, but only the condyle remained on the surgical side. The radiograph demonstrates how the condyle can be unseated from the fossa by the stronger contralateral muscles.

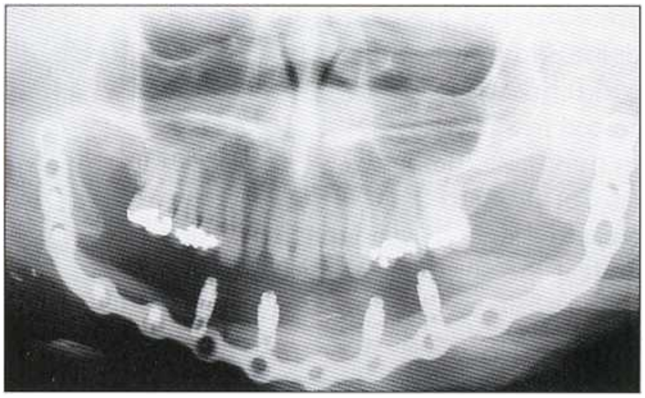


Fig 12-3 This patient had bilateral osteoradionecrosis, immediate resection, and reconstruction with a fibular graft. The minimal bone height is evident.

oral remnants of bone that exist proximal to the resection arc likely misplaced due to muscle pull and are also surrounded by scarred, fibrotic muscles and soft tissue. The surgeon has a difficult assignment to release the scar tissue from the residual mandible to reposition it to its normal position. The scar tissue in the oral cavity and neck must be released and repositioned laterally to allow appropriate placement of the bone graft. Despite release of the scar contractures, rarely is there enough elasticity in these tissues to allow placement of the mandible and graft in the appropriate position; additional soft tissue must often be grafted. Regardless of whatever surgical templates may be employed, this reconstruction often results in compromises in final position. When no ramus is present or only the condyle is present, and when scarring has occurred in the mandible area, final range of motion and posture of the mandible is additionally compromised, The patient should not be discouraged from proceeding with the surgery because there may be improvement of facial form, and the malposition can be somewhat compensated by the oral prosthesis. However, they must be fully informed that results will not be ideal and that they might require additional surgery to manage soft tissues and microstomia or to reposition a severely mal- posed bone graft.

In delayed reconstructions, clinicians must determine the importance of releasing the condylar remnant. This segment lies perilously close to the facial (seventh cranial) nerve, which can easily be damaged. Given the minimal improvement in function when grafting to a small condylar remnant and the devastating functional sequelae of facial nerve paralysis, no attachment of the graft to the condyle is recommended. The bone graft should end below the condyle and glenoid fossa, with no attempts to fix the bony segments or to place the end of the graft in the fossa.

Patients may present after bony reconstruction with interarch discrepancies. In immediate fibula graft reconstructions, a considerable inter- arch discrepancy may exist that places the graft buccal to the maxillary alveolus. The fibula graft lacks height when compared to the residual mandible. It measures between 10 and 15 mm in height and in width, but the shape is pyramidal and therefore narrower at the occlusal surface. Anatomically it resembles an atrophic edentulous mandible. The fibula is grafted to restore the inferior border of the mandible, which is necessary to restore facial form (Fig 12-3). However, this tends to place the fibula buccally in the plane of the cheek and does not support the lower lip. Due to the lack of height and the buccal position of the bone, increasing vestibular height with a vestibuloplasty is not possible; a complete mandibular denture is rarely stable without the aid of implants. Since the bone graft is in a buccal position in the cheek, implants placed distal to the premolar area are likely to present constant soft tissue and infection problems. If there is enough width in the bone graft, implants should be placed toward the lingual aspect of the bone graft to minimize the buccal position.

The iliac crest graft offers the capability for increased bone height compared with the fibula graft if the surgeon elects to harvest more bone. Due to the appearance of the donor-site defect, however, some surgeons attempt to split the width of the crest at the donor site to maintain donor-site contours. The split crest may not have any greater width than the fibula graft and as such may also be in a buccal position in the cheek. When placing implants, the same considerations may be necessary.

Interarch discrepancies can occur in immediate surgical reconstructions when the preoperative position of the mandible is not maintained and the relationship of the maxilla to the mandible is inappropriately estimated during the reconstruction. The graft may contact the posterior maxillary arch, preventing the patient from closing the mouth. In a lesser interarch error, the arches may touch at the vertical dimension of rest; however, prostheses cannot be fabricated. This error commonly occurs when the inferior aspect of the ramus has been resected and the reconstruction has failed to recreate the vertical height of the ramus. In delayed surgical reconstruction, the cause and effect are similar. The loss of preoperative orientation of the mandibular segments and interarch relationship is inevitable without a planned, delayed reconstruction that maintains the preoperative relationship of the mandible to the maxilla.

Mandibular Resections: Prosthetic Considerations

Processed Bases for the Maxillofacial Patient

Processed bases have been shown to add to the accuracy of interocclusal records in routine complete dentures. In the maxillofacial prosthetic patient who has loss of supporting bone, unusual intraoral contours due to resection and reconstruction, and gross malposition of occlusal contacts, processed bases are necessary to determine occlusal plane, buccolingual tooth position, lip support, esthetics, and occlusal records. Tooth positions are often compromised as the clinician attempts to harmonize facial form, esthetics, speech, and mastication that have been severely disrupted by surgery. The conventional trial base requires blockout of undercuts only on the alveolar ridge. The mandibular trial base for the maxillofacial patient often requires blockout of the trial base at the periphery of the base where unusual undercuts exist. In this way the border extension is decreased, decreasing surface area needed to optimize retention and stability of the prosthesis. It does not allow determination of the relationship of the final prosthesis periphery and the buccal or lingual tooth position (Figs 12-4 and 12-5).

In the maxillofacial patient, overextension of the denture base onto mobile tissues severely decreases stability. Undertaking maxillomandibular relationship records with processed bases allows the clinician to evaluate the optimal retention and stability prior to adding the wax rims or dentition. Ideally the bases should not move with movement of the mandible and oral cavity structures. The overextended bases should be reduced until the bases are stable. As the wax rims are contoured to meet the required functional compensations, the clinician can determine if retention and stability are adversely affected. It may become evident that some of the compensations will not be possible if the prosthesis is to remain in position. The clinician can also begin to assure the patient through demonstration that ideal tooth position and masticatory function is being optimally assessed, though compromises must be accepted.

Patients with mandibular resections and reconstructions often require the prosthesis to compensate for loss in alveolar bone quantity or the deviation/rotation that exists in the postoperative position of the mandible. Dislodging forces generated on this prosthesis are not observed in routine prosthesis fabrication. Extension beyond the peripheries of the prosthesis may be required

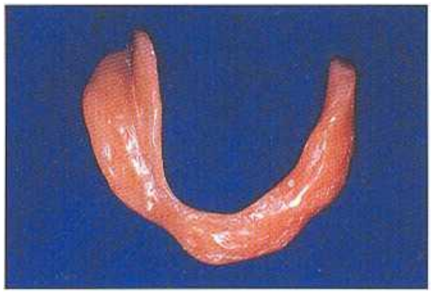
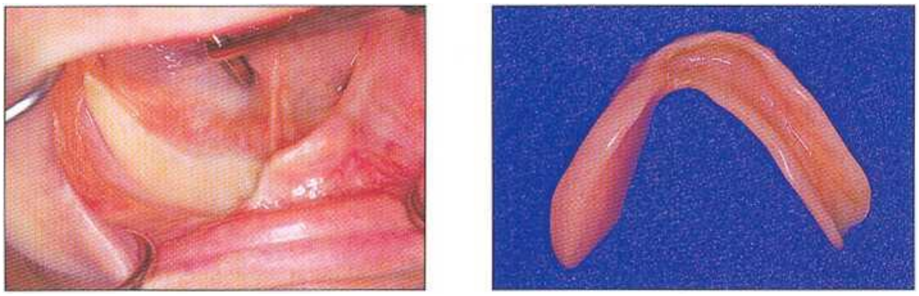


Fig 12-4 The processed base is for a patient who had a coronal marginal mandibulectomy involving 75% of his alveolar ridge. A portion of the resection also included the lingual cortex, creating an unusual contour in the processed base.



Figs 12-5a and 12-5b This patient had a marginal mandibulectomy resurfaced with a split-thickness skin graft. The scar band that formed on the buccal and lingual of the defect created a narrow concave defect.

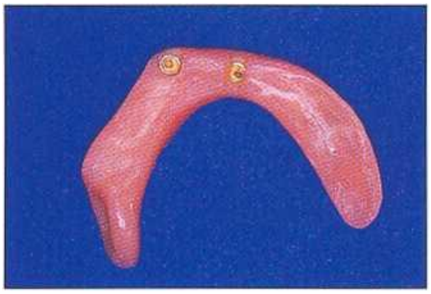


Fig 12-6 Two implants were placed in a patient following a secondary surgery to debulk the fibula-graft soft tissues. Incorporating the implant retention in the processed base allowed critical evaluation of the support that could be gained for an inverted lower lip.

to support the lip. To add stability to the prosthesis, occlusal contact may need to be significantly buccal or lingual to normal anatomic landmarks that usually denote the occlusal table. Bilateral support in the mandibular arch may be nonexistent due to the lack of bony reconstruction, and bilateral tooth contact might be nonexistent due to rotation of the mandible.

The need for processed bases exists for the edentulous and partially dentate patient, and is important for both maxillary and mandibular arches. Even though the mandible has the surgical defect, processed bases should be employed for the edentulous maxilla because unusual inter arch relationships, such as unilateral contact on the maxilla, can unseat the maxillary prosthesis. Removable partial denture fabrication in the resected mandible can also benefit from processed trial bases. Retention is less of a problem because the remaining dentition supports the prosthesis, but deciding upon the appropriate buccolingual tooth position can be a problem with blockout of the prosthesis peripheries. Patients who have implant-retained prostheses should have the retentive elements incorporated in the processed base. If the retentive elements are not used at the maxillomandibular relationship and try-in appointments, the clinician cannot optimize the advantage of implants when determining the necessary displacement of soft tissues of the face (Fig 12-6).

Processed bases: Technique

The bases can be waxed on the master cast and processed in heat-processed acrylic resin. Implant prostheses will require using analogues in the master cast similar to routine denture construction. If the retentive elements arc to be adapted and cured in the mouth, these processes need to be accomplished prior to maxillomandibular records. The processed bases should be taken to the mouth and evaluated for retention and overextension. Remount casts will be required. For removable partial dentures, an intraoral pickup impression will be required after the processed base is tried in. This remount cast will be used for subsequent records, to set teeth, and to adjust occlusal processing errors. The base should not be processed on the remount casts because these casts have usually been blocked out to allow removal of the processed base and the framework. The prosthesis may be invested without a cast, or a second pickup impression can be made of the removable partial denture at trv-in. This impression can be poured with no blockout on the edentulous area or around the framework. The framework is protected by being well adapted to the new cast and covered in the drag of the flask. The analogues should be placed in the implant denture base prior to flasking the base. The dentition can be processed to the processed base with autopolymerizing acrylic resin or the same heat-processed resin at a lower temperature. This will decrease distortion due to release of polymerization stresses.

Marginal Mandibulectomies

The ideal prosthesis-bearing surface for the marginal mandibulectomy patient is the split-thickness skin graft; it is thin, firmly attached to the mandible, and will not move with movement of the tongue, floor of the mouth, or cheek. If the patient is dentate except for a posterior marginal mandibulectomy, the need for a prosthesis is not as compelling. When the defect includes the loss of only a few posterior teeth, the surgeon may elect to close the site primarily. Primary closure precludes the need for a donor site but places mobile mucosa over the mandible with the floor of the mouth and check, forming a confluent tissue surface and obliterating base support for the prosthesis. If the patient is edentulous, however, a skin-grafted mandibular surface is critical for increased surface area and stability of the prosthesis. When this site is closed primarily, a denture cannot be placed over the mobile tissue because the denture will be unseated (Fig 12-7). When there is considerable height between the remaining ridge and the resection, a skin-grafted surgical defect may create a concave contour that can actually offer lateral stability to the prosthesis. It is critical that the patient's desires about postoperative mandibular rehabilitation be clarified with the surgeon. If the patient desires prosthetic restoration of the surgical area, a skin graft is necessary.

When the mandible has been previously irradiated or when soft tissue is necessary to restore the bulk of associated soft tissue resection, primarily the tongue and floor of the mouth, a flap may be necessary. A bulky flap will preclude any prosthetic intervention in the defect area. Dentate patients may not be interested in a posterior prosthesis. However, missing anterior dentition compromises speech, bolus control, oral competence of the lips, and esthetics. If some unilateral posterior dentition remains, a removable prosthesis can be retained by the existing dentition, and the anterior aspect of the reconstruction can be used to support the prosthesis. This reconstructed tissue may be mobile and displaceable, but a functional reline impression can be made on the processed base to maximize the displacement of the flap (Fig 12-8).

This functional reline can be achieved intra- orally using a composite acrylic resin (Triad, Dentsply, York, PA). The area requiring reline should be cut back 3 to 4 mm in depth and a heavy finish line cut into the prosthesis bordering the area. The Triad rclinc material (sheet) can be cut to fit the reline area. The prosthesis surface should be cleaned with methyl methacrylate monomer and the reline material positioned. This prosthesis should be dipped in a hot-water bath to allow the material to be shaped with functional movements. The steps can be repeated and excess material trimmed away prior to light curing.

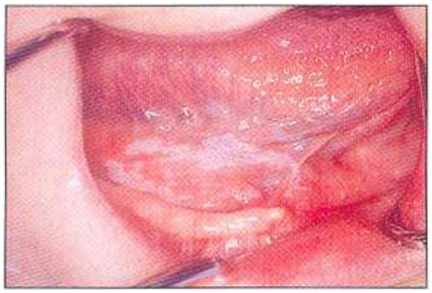
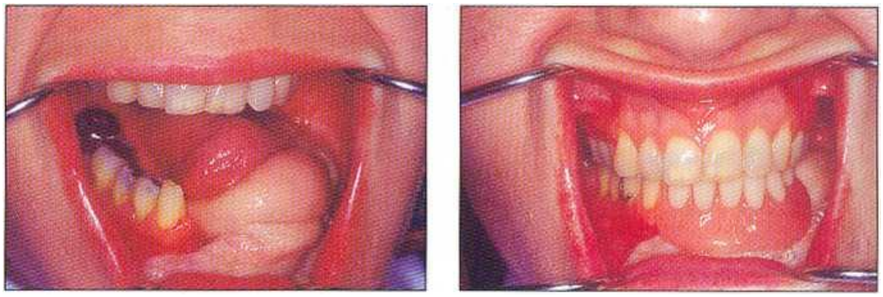


Fig 1 2-7 This edentulous patient had a left marginal mandibulectomy, but it was closed primarily with floor-of-the-mouth and cheek mucosa. The tissues are very mobile over the mandible and preclude adequate stability for a complete denture.



Figs 12-8a and 12-8b This irradiated patient had a second primary cancer and was treated with a marginal mandibulectomy and floor-of-the-mouth resection. A mi- crovascular free-radial forearm flap was used to cover the previously irradiated mandible and reconstruct the floor of the mouth. Several months postsurgery, she was fitted with a removable partial denture that compressed the flap to replace missing anterior dentition.

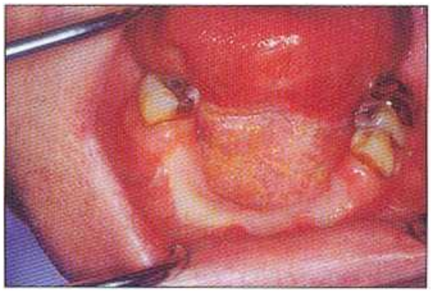


Fig !2-9a The marginal mandibulectomy resurfaced with a skin graft is the ideal bony coverage if no associated structures require reconstruction and if the mandible has not been irradiated.

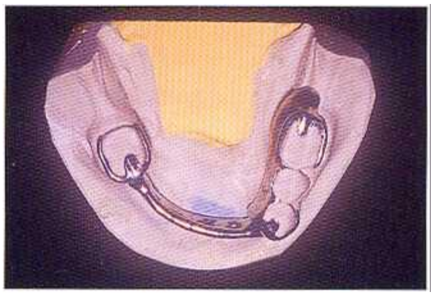


Fig 12-9b The acrylic-resin retentive element can be placed vertically to accommodate the narrow buccolingual width. This framework modification can also serve as a rigid major connector.

Removable partial denture frameworks for the marginal mandibulectomy patient should follow routine parameters for framework design related to support, stability, retention, reciprocation, and minor and major connectors. Retentive mesh elements of the framework should be modified to offer strength when a midline resection is being considered. In this midline situation, the retentive element also functions as the major connector. Because the marginal mandibular resection is quite narrow in a buccolingual direction, the width needed for the framework is lacking. It is possible to place the retentive acrylic-resin element of the framework in a vertical plane rather than a horizontal plane. A large open lattice can be waxed to a height of several millimeters. The design can be narrow so as not to impinge on the buccal or lingual width of the mandible, but the vertical height offers strength to serve as a major connector (Fig 12-9). An altered cast impression can be performed from this framework with a functional impression of the height and width of the entire bony alveolar ridge formed during border molding to assess lip support during speech and swallowing. This impression can be transferred to an altered cast.

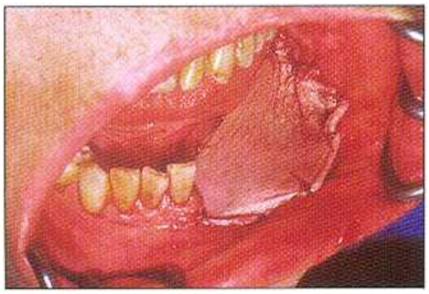


Fig 12-10a A skin graft is sutured to the periphery of the marginal mandibulectomy. A surgical stent with interdental wiring was used to support the graft.

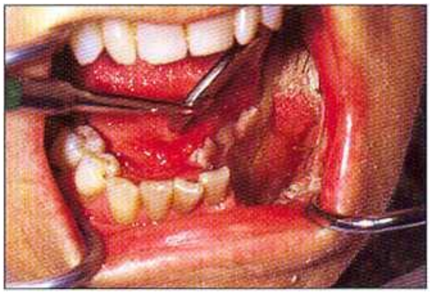


Fig 12-10b The graft as observed 5 days after surgery.

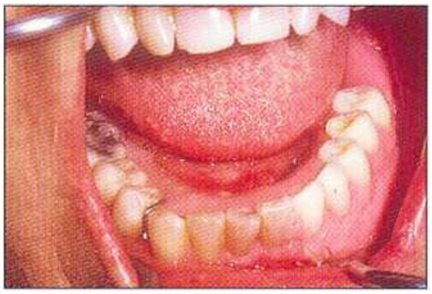


Fig 12-10c An interim prosthesis is possible for dentate patients. To limit postoperative visits over the next few months, the tissue-conditioning material should not extend beyond the buccolingual width of the cut mandible because the tissues will eventually contract to that border.

Maxillomandibular Relationship Records

Routine recording materials can be used for the marginal mandibulectomy patient. Centric relation records should be possible because the temporomandibular system is not compromised with surgery. Lip support should be assessed, and restoration of the alveolar process and dentition is necessary. Often the lip and cheek require support buccal to the bony support. This displacement of the lip is usually possible when an implant-retained or removable partial denture is used. An edentulous prosthesis may be dislodged when attempting to displace the lip or check. If the mandibular anterior teeth must be lingually positioned, if may be necessary to decrease the anterior lip support in the maxilla to achieve better speech and esthetics.

Asymmetric tooth display may be evident in the mandible due to contracture of the lip, lack of lip support, or injury to the marginal mandibular branch of the facial nerve. This is commonly seen with ipsilatcral neck dissections that accompany intraoral tumor resection. The occlusal plane may be minimally modified to decrease tooth display, but gross modifications may lead to cheek, tongue, or lip biting.

Optional Surgical Prostheses

In the case of dentate patients, a surgical stent can be delivered during surgery; an interim prosthesis can be delivered following surgery. For a stent, a cast is modified to remove the dentition as outlined by the surgeon. The skin graft can be bolstered with a tissue-conditioning material relining the surgical stent (Tru-soft, Harry J. Bosworth, Skokie, IL). If the patient is dentate, the prosthesis can be secured to the dentition with 24-gauge interdental wires. Restoration of the dentition with the stent is not necessary and probably not advised as it is difficult to achieve atraumatic occlusion intraoperativelv. An acrylic-resin interim partial denture can be fabricated from the presur- gical impression and refined with tissue conditioner upon removal of the surgical stent. The defect will initially appear wide, but the lateral borders of the defect will contract to the width of the cut mandible. Care should be taken to place the refine material only as wide as the cut edge of the mandible. An increased number of adjustments and refines will be necessary if the width of the prosthesis is extended beyond the edge of the mandible (Fig 12-10).

'Fhe skin graft in the edentulous patient is usually secured with a bolster of tissue-conditioning material fabricated intraoperativelv or a gauze bolus. Either functions very well. It is possible to create a baseplate that can be refined intraopera tively and secured with transmandibular wires or sutures. Unfortunately, insertion of a complete denture is not possible until the surgical-site tissue contraction is completed. This may take 2 to 3 months. If adjuvant radiotherapy is required, prosthesis fabrication should not proceed until the mucositis has subsided, possibly 2 to 4 months after irradiation.

Discontinuity Mandibulectomies

A universal prosthodontic axiom for the edentulous discontinuity mandibulectomy patients is that a prosthesis should not extend onto mobile tissues that are unsupported by bone. These tissues may be static when the mandible is in a static position, but as the mandible or structures of the oral cavity move in function, these unsupported tissues in the defect area will also move and unseat the prosthesis. An exception can be made for the partially dentate patient and for patients with implant prostheses; anterior teeth can be cantilevered to support the lower lip.

The most common observation of patients who have unilateral discontinuity mandibular defects is the characteristic deviation of the mandible to the surgery side and rotation of the mandible interiorly. The mandible actually shifts laterally to a greater extent at the anterior dentition and less at the second molar. The shift to the defect side is also greater as the mandible opens. Centric relation occlusion does not exist because only one condyle is functioning to guide the mandible. Interestingly, patients do have proprioception for a repeatable position if asked to repeatedly tap their teeth together. However, when asked to open wide and close the mandible, they are likely to contact a repeatable area, but not a repeatable point contact. This repeatable area is usually palatal to normal intercuspation due to surgical closure and the medial pull of the pterygoid muscles on the contralateral condyle and ramus. It is this repeatable surface area that clinicians target when rehabilitating the mandibulectomy patient.

Patients often have an Angle Class II appearance. Due to the deviation and rotation of the mandible, the chin is in a slightly lateral position; therefore, the projection of the chin is decreased. The patient exhibits a Class II anterior occlusion and facial form. When planning treatment for such a patient prior to surgery, the ipsilateral maxillary second and third molars should be considered for extraction. There will likely be some tissue contraction of the area with impingement on the buccal mucosa or of the dentition on the soft tissue flap. These nonfunctional teeth arc also subject to postoperative irradiation. In their nonfunctional state, they arc more a liability than a prosthodontic advantage.

Palatal Augmentation Prostheses

Patients who have mandibular resections often have difficulty' valving the tongue against the palate for appropriate speech sounds or to manipulate the food bolus in mastication and swallowing. These functional deficits are due to the accompanying surgical defect that commonly occurs in the tongue and floor of the mouth due to the extent of tumor in the soft tissues and mandible. The tongue may have a loss of tissue bulk and motor movement due to resection of tissues and nerves. (For a discussion of treatment for the glossectomy patient see Chapter 14.) It may be tethered due to contraction. It may be nearly replaced by a nonmobile flap. All of these conditions restrain the tongue from elevating and making precise rotary movements necessary to manipulate the food bolus. In addition, the mandible is deviated in the discontinuity defect and the tongue no longer contacts the palate in the midline. When the mandible does not return to its midline position and the tongue has limited range of motion, the tongue cannot make contact with the contralateral side of the palate. In addition, it cannot move food onto the contralateral occlusal surface for mastication.

All mandibulectomy patients should be considered for palatal augmentation prostheses if they have residual, food on the palate or in the sulci of the oral cavity, complain of swallowing difficulties, or have impaired speech sounds. This prosthesis involves shaping the contours of a palatal baseplate, either retained by the maxillary dentition or integrated into the base of a maxillary complete denture. In a normal tongue-palate relationship, the palate cups around the tongue at rest and in function. The contours of the palatal augmentation should also cup around the residual tongue. In dentate patients, the occlusal vertical dimension will determine the thickness of the palatal augmentation. The thickness is increased until the tongue contacts the palate in swallowing. Where tongue bulk is lacking, wax will likely be thicker in the corresponding area of the prosthesis to gain tongue contact. Contact can be checked on the palate by pressure-indicating paste. It often requires trial and error to determine if pressure areas need to be reduced or if areas without contact need additional wax. The range of motion of the tongue should be examined. It may be obvious that the tongue cannot begin to contact some areas of the palate because the tongue does not move in that direction. The lateral border of the palatal cup will occur at the most lateral position of the residual tongue. Refinements in speech will evaluate the posterior contact of the palate *(k* sound). During speech, air may leak laterally along the borders of the deviated tongue. These areas can often be visualized as saliva escapes where the palate does not cup the tongue during speech *(s* and *sh).* Slight additions of wax should be made to the augmentation to stop the lateral air escape during the *s* sound. Anterior contact for the rand *d* sounds should be added at the anterior elevation of the residual tongue, which is the new functional tongue tip. As each small addition of wax is added in these areas, the additions must be checked for a full range of speech sounds and swallowing with pressure-indicating paste. Additions of material may improve some sounds but begin to distort others. Compromise in some sounds will be necessary to achieve optimum speech. Shaping the augmentation with the assistance of a speech pathologist and follow-up speech therapy are beneficial.

The Dentate Patient

Since the dentate patient is only missing dentition on the resected side of the mandible, a mandibular prosthesis is not usually required to replace lost posterior teeth nor would it be stable on the remaining unsupported soft tissues. If the patient requires anterior mandibular dentition to support the lip to improve speech and lip competence, a cantilevered prosthesis of anterior teeth only may be retained by the residual dentition.

Mandibular deviation and rotation can cause occlusal disharmonies that result in an increased vertical dimension, an inability to close the lips, and anterior negative vertical overlap. This occurs when the patient does not achieve maximum in- tercuspation on closure. Depending on the amount of deviation, the mandibular buccal cusps (usually the buccal inclines) contact the maxillary lingual cusps on the lingual or buccal inclines. When the contact is within the maxillary occlusal table, the mandible sometimes slides into appropriate position, but it becomes locked by a particular tooth (usually the second molar) and the mandible is not free to contact the remaining dentition. Sometimes deviation is such that the canines or premolars on the surgical side make contact and lock the mandible in position without any contact on the contralateral dentition. Gross occlusal adjustments should be performed to achieve maximum intercuspation within the limitations of the deviation process. The adjustments should be performed in an upright head position, and deviations of the mandible will be accentuated by changes in posture. Because an upright position is the most functional head position for the patient, the dental chair should not be inclined. Achieving the correct vertical dimension of occlusion is necessary to gain lip closure. As these adjustments are made, the mandible may gradually return toward the appropriate alignment with the maxilla. When the occlusal adjustment is completed, it is still likely that contacts will be against cusp tips and inclines rather than cusp-fossa relationships. The anterior negative vertical overlap may persist due to the inferior-anterior rotation of the residual mandible.

If the mandible is deviated such that the contralateral dentition is palatal to the maxillary dentition after occlusal adjustment, a palatal prosthesis can be fabricated that creates an occlusal table palatal to the maxillary teeth. A processed baseplate with wire retention, which covers the

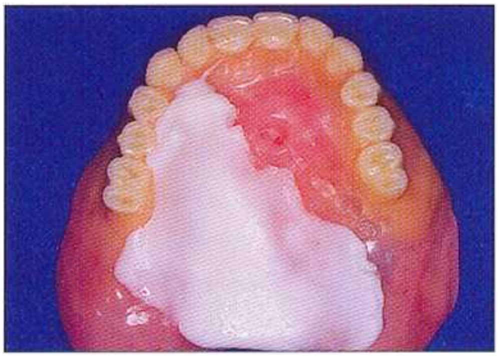


Fig 12-11 Maxillary prosthesis providing an occlusal table palatal to the dentition for a patient who had a discontinuity mandibulectomy reconstructed with a microvascular radial forearm flap. Tissue conditioner was placed for the patient to mold in swallowing and speech. The tongue had good mobility and was not tethered by the free flap; however, it was observed that the tongue had deviated to the right side of the palate along with the deviated mandible.

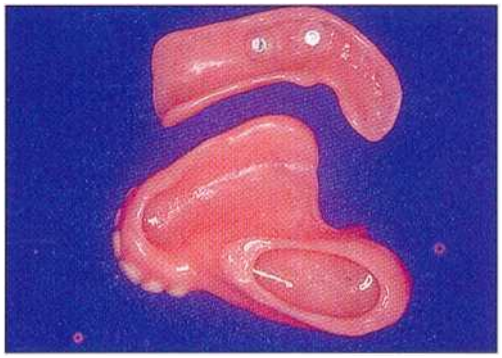


Fig 12-12 Edentulous maxillary obturator and mandibular resection prosthesis worn by a patient who required almost complete extractions in the mandible prior to irradiation. Two teeth were maintained for magnetic retention of the mandibular prosthesis.

palate and plates all of the palatal aspects of the maxillary teeth up to the level of the occlusal plane, should be fabricated. It should be adjusted so as not to impede the movement of the mandibular shift toward the normal side. The patient is instructed to move the mandible laterally toward the nonsurgical side. No manual manipulation should be used except initially to assist the patient in understanding the maneuver. Repeated movements will allow the clinician to add wax to the baseplate to establish the occlusal contact. The final occlusal table is formed with soft wax, and the patient is instructed to make repeated closures into it. Excess wax can be trimmed from the area and the wax reheated to establish contact points. The contacts may be quite broad, and there may also be a slide of the mandible from initial contact to final maximum contact. This is a common finding, and the mandible should be allowed this freedom. The need for a palatal augmentation prosthesis should also be assessed. Tongue contact with the prosthesis can be optimized for speech and swallowing (Fig 12-11), and the occlusal table and augmentation can be processed. Insertion of the prosthesis should evaluate contact. Occlusal adjustments can be made intraorally because the prosthesis is stable. Contact may be entirely on the prosthesis or a combination of prosthesis and maxillary dentition.

Mandibular Prostheses

Processed bases are ideal for the edentulous patient because prosthesis-support surface area is limited. For patients requiring a removable partial denture, a processed base may be required if there is limited mandibular dentition. If the clinician has the opportunity to plan treatment for the patient prior to resection, maintaining key mandibular dentition to support the prostheses is recommended. Noting that the patient may require postoperative irradiation, dentition with gross caries and periodontal disease should be extracted. Molars in marginal condition are particularly detrimental to patients due to the risk of future osteoradionecrosis. Mobile, periodontally involved incisors are also of little prosthetic value and may be a necrosis problem in the future. In contrast, nonmobile canines or premolars, even with generalized horizontal bone loss, can offer significant retention to patients having to use unilateral mandibular prostheses. Routine periodontal and endodontic therapy should be implemented to maintain these key teeth. Their crown-root ratio-can be reduced, often without placing crowns, and they can serve as prosthesis abutments. Alternatively, they can receive elective endodontic therapy and be restored with a coping and magnet system (Fig 12 12). Many patients can be motivated to maintain these few teeth despite a past history of dental neglect. Daily fluoride therapy should be added to their dental regimen along with intense hygiene instruction and demonstration.

The maxillary arch should be evaluated for an augmentation prosthesis. When a complete maxillary denture is fabricated, some compromise in maxillary lip projection should be made to decrease the Class II appearance.

Maxillomandibular Relationship Records

If the patient is edentulous in the maxilla, a processed base should be fabricated and the occlusal plane established similar to a routine complete denture. If the patient has a removable partial denture, the same parameters should be considered. If the patient is edentulous in the mandible, a processed record base should be used to achieve maximum stability. Because the record will be transferred to an articulator to add teeth to the maxillary, mandibular, or both prosthescs, it is important that the record be made at the established vertical dimension of occlusion. The patient's path of closure is not a hinge motion, rather a diagonal path in the sagittal plane. An articulator cannot duplicate this motion, but it can be used to create simultaneous contact at the vertical dimension of occlusion established in the interocclusal record.

Determining the vertical dimension of occlusion should rely on lip competence, facial appearance, and speaking-space parameters. Partially dentate patients with no posterior occlusion and mandibular deviation may have a preprosthetic occlusion that places the mandibular teeth against the palatal mucosa. One should establish a vertical dimension that will relieve the palatal mucosa of occlusal contact and establish lip competence. With the loss of tongue bulk, the residual tongue does not assist in establishing the appropriate vertical dimension. Lip competence and appearance should be the primary determinant of vertical dimension, as other parameters might be distorted due to the surgical procedure. Lip closure is a function of support by the ante

rior dentition and the vertical dimension. When establishing the position for prosthetic anterior dentition, the maxillary teeth should be placed in a slightly palatal position so as not to accentuate the Class II appearance or compromise lip competence. The vertical dimension of the posterior dentition and the vertical dimension established by the tongue in contact with the palatal augmentation should then be established to coincide with the vertical dimension necessary to maintain lip competence.

The mandibular record base should be systematically modified until the wax rim makes even contact with the maxillary dentition or at the desired vertical dimension of occlusion. Repeated closures will be necessary in a head-upright position. The patient should be advised to close the mandible toward the nonsurgical side of the maxilla, but there should be no attempt to guide the mandible. The mandibular wax rim should make even contact with the maxillary arch. In the edentulous patient, it will be evident that this mandibular occlusal plane corrected the rotation of the mandible in the anterior area when the casts are mounted on the articulator. The height of the anterior occlusal rim will be greater than the posterior occlusal rim and will eliminate the negative vertical overlap. Due to mandibular rotation, the teeth on the edentulous posterior mandible will likely be set over the buccal shelf.

To ensure that the record is made at the established vertical dimension of occlusion, no interarch recording medium should be used. An interarch recording medium will create a contact that is likely not reproducible due to unilateral condylar guidance. The wax rims should have large defined notches placed on the facial of the rims. The patient should close into the predetermined reproducible position, and impression plaster or another injectable recording medium that will set rigidly should be injected into the entire vestibule and notches. This will likely require two clinicians monitoring the patient to maintain the desired occlusal position and retract the cheeks to allow space for the recording medium. The recording material can be broken from the bases and rims to remove the bases from the

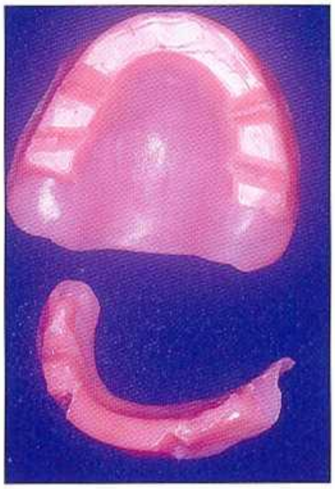


Fig 12-13a *(left)* Wax rims should make complete contact at the established vertical dimension of occlusion. The recording indices should be placed on the buccal of the occlusion rims.

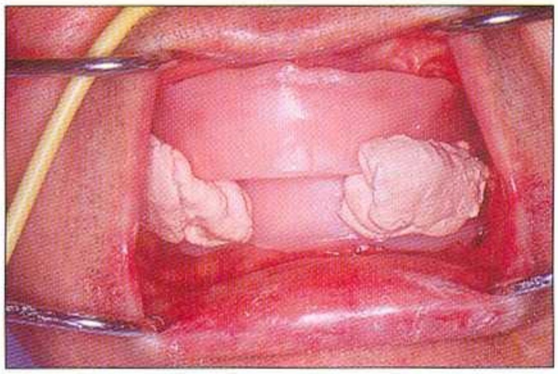


Fig 12-13b *(right)* The patient is instructed to close and maintain the reproducible centric occlusion established by the wax rims while the clinician injects impression plaster into the buccal indices.

month and then reassembled in the laboratory. If the patient is dentate or partially dentate in either arch, the buccal surfaces of the teeth can be injected with the recording medium (Fig 12-13).

The clinician should have patience at the try- in appointment. The entire maxillomandibular relationship procedure may require repeating. Multiple compromises of vertical dimension, speech, anterior tooth position, and lip competence may need to be made and reassessed. The goal is to optimize all prosthetic parameters for the patient, so additional try-in appointments may be necessary. The palatal augmentation should be added to the maxillary prosthesis after establishing satisfactory tooth positions. The dentition and augmentation can be processed to the record bases. If processed bases and remount casts are used, the processing error may be corrected on the remount casts prior to insertion.

Reconstructed Mandibulectomy

The major advantage to bony reconstruction is that it re-establishes facial form and allows a framework for intraoral and extraoral structures to achieve adequate speech and swallowing. This is particularly critical for discontinuity defects that include the anterior mandible. The hyoid muscles that elevate the larynx during swallowing must be reattached to the mandibular graft. The anterior mandible keeps the lips and root of the tongue from collapsing, thereby improving oral bolus control. Patients sometimes perceive the replacement of the dentition as the primary reason for the mandibular bone graft, but they should be forewarned that the bone graft may be only the first of many surgical procedures before the graft bed is satisfactory for prosthetic intervention. Unfortunately, many patients desire prostheses but are not willing to undergo more surgical procedures that add financial and emotional burdens. But before the graft can be used for prosthesis support, debulking and skin-graft surgeries are often necessary. When patients have had post-

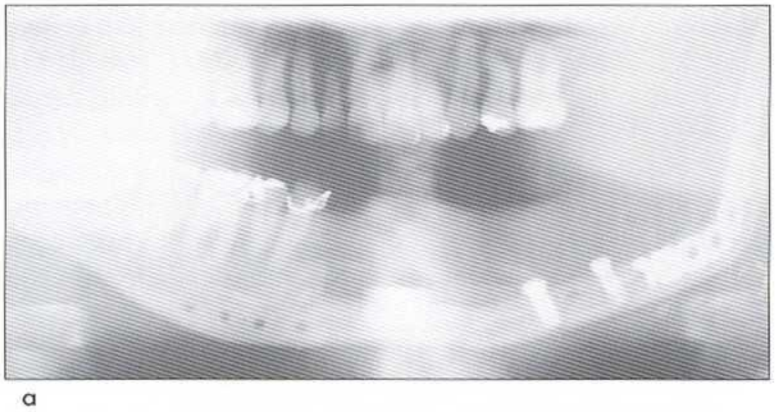
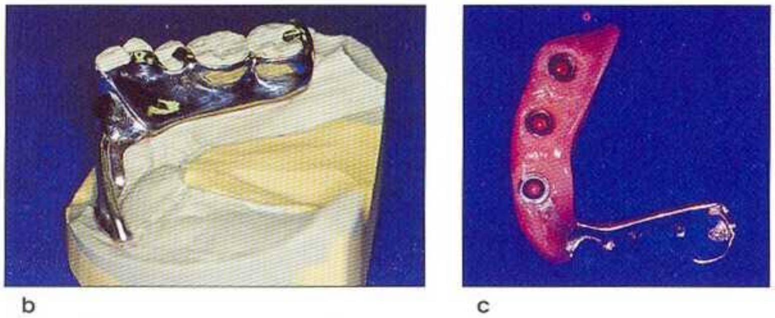
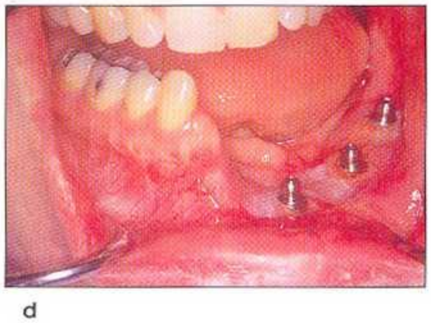


Fig 12-14a Radiograph of a patient who had the plate removed and three implants placed into the fibular graft 6 months after reconstruction. Molars on the ipsilaferal side are frequently extracted during the reconstructive surgery because of their nonfunctional nature and risk of impingement on the soft tissues of the osseous flap.





Figs 12-14b to 12-14d A unilateral partial denture can be retained by ball attachments on the implants and one clasp on the remaining dentition. The tooth adjacent to the defect does not require a clasp for retention. The proximal guide plane on this tooth is not blocked out to allow placement of teeth immediately adjacent to it. The acrylic resin retentive element is positioned vertically and lingually to the ball attachments.

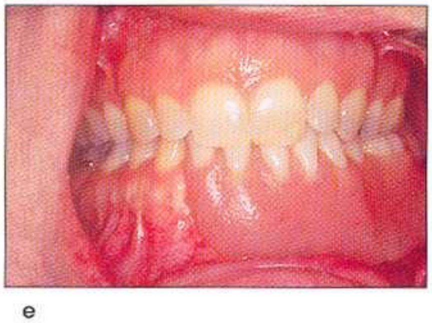
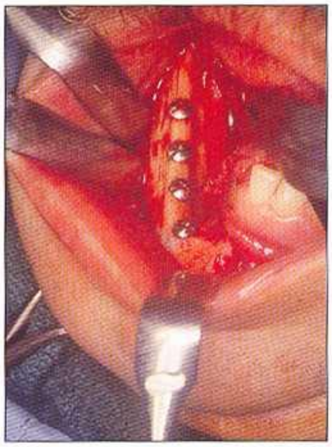


Fig 12-14e Final prosthesis reveals excellent anterior esthetics and the long lever arm of the prosthesis required to restore the alveolus and dentition. A fixed prosthesis would likely tax the short implants.

operative irradiation, these preprosthetic surgeries increase the risk of soft tissue necrosis and osteoradionecrosis. Postoperatively, mastication and deglutition may be a problem due to lack of adequate tongue movement. Patients must be advised that intraoral procedures to prepare the bone graft tor implants or to support a prosthesis may have little effect on mastication due to tongue and oropharyngeal deficits.

Edentulous patients with bone grafts usually require implants to retain a denture. To prepare the graft for implants, the reconstruction plate must be removed, and tissues over the graft must be debulked and replaced with a skin graft (Fig 12-14). The osteotomy sites in the graft must heal before the plate can be removed and before implants can be placed in these sites. At MD Anderson Cancer Center, the shortest amount of time elapsed from resection to delivery of an implant prosthesis was 14 months. The irradiated patients who received implants have been those patients whose mandibles were grafted after necrotic bone was resected due to osteoradionecrosis. The implants were placed in the non- irradiated grafted bone. A small percentage of patients who received bone grafts were patients



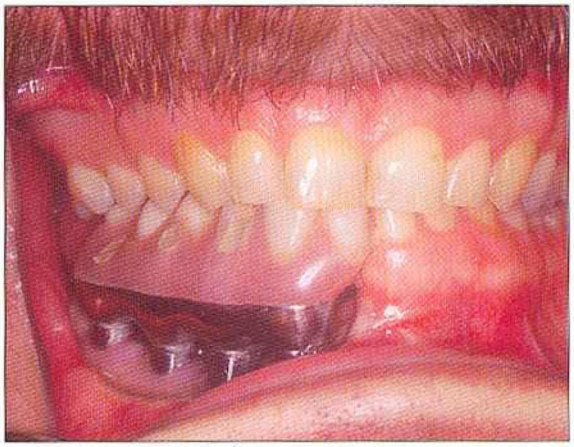
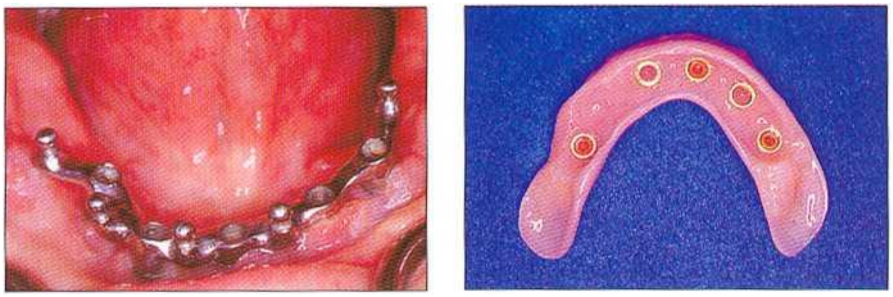


Fig 12-15a *(left)* The narrow width and pyramidal shape of the fibula graft is shown.

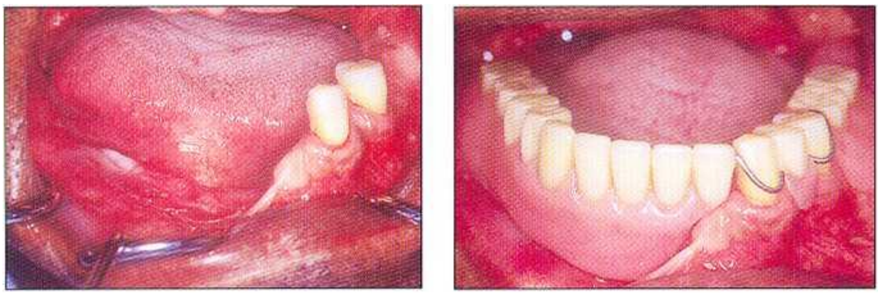
Fig 12- 15b *(right)* The bone graft is buccally placed to achieve excellent extraoral contours. The canine had to be light cured to the prosthesis after the most anterior abutment screw was placed. It was not possible to reach this abutment screw, which was greater than 2 cm inferior to the occlusal plane. This patient had air escape between the implant abutments during speech. He required an additional removable prosthesis magnetically attached to the fixed prosthesis to replace the missing alveolar process.



Figs 12-16a and 12-16b This patient was reconstructed with an iliac crest graft. Following irradiation she had hyperbaric oxygen therapy. Due to the previous irradiation and quality of bone in the iliac crest graft, all implants were splinted and ball attachments were cast info the bar in harmony with a diagnostic waxup.

with sarcoma of the mandible. These patients were not irradiated, and the majority of them received implants. For myriad reasons, fewer than 15% of the 218 mandibular bone-graft patients treated in a 10-year period received implants.

Fixed-implant prostheses can be used in this population, but many patients have moderate to severe decrease in oral opening due to accompanying scarring and fibrosis of soft tissues and muscles of mastication. The prosthesis often requires considerable vertical height, replacing teeth and alveolar process. In these instances, it is often difficult to gain intraoral access for screwdrivers that must pass through the occlusal surface to an implant screw 2 cm inferior to the occlusal surface (Fig 12-15). A removable prosthesis allows control of the contours of the alveolar process needed to achieve adequate facial support and airflow during speech (Fig 12-16). A long lever arm is created on short implants to replace the alveolus and the dentition. Implant-retained prostheses can gain support from the contralateral natural dentition and the remaining mandible. Due to limited oral opening, patients may have hygiene problems that are accentuated with a fixed prosthesis. Given these difficulties, few patient situations have been acceptable for fixed- implant prostheses.



Figs 12- 17a and 12-17b This patient received a fibular graft reconstruction. A mandibular partial denture was fabricated and extended to cover the fibula graft. The soft tissues over the bone graft are mobile but do not unseat the prosthesis due to the maintenance of two key natural teeth.

An alternative to the implant prosthesis is to maintain key mandibular teeth, such as canines or premolars, on the unresected side of the mandible to support a removable mandibular prosthesis. Retentive unilateral removable partial denture prostheses can greatly enhance speech, swallowing, and mastication. If the soft tissues over the bone graft are not too bulky, the removable partial denture can be extended to cover the bone graft without debulking surgery (Fig 12-17).

Conclusion

Prosthodontic modifications to routine prosthodontic procedures can be accomplished to compensate for deficits that are not correctable with surgical reconstruction. Rehabilitation of the rudimentary functions of speech and swallowing should be paramount for all clinicians. Dentists should strive to maintain existing mandibular dentition because it will be important to retain prostheses that are necessary to support the lips and stabilize the mandible for swallowing.

Anterior dentition is important to assist in airflow during speech, especially when tongue movements are compromised. While prostheses can replace dentition to aid in mastication, the effect on mastication is a secondary prosthetic benefit compared with the rehabilitation of the rudimentary functions of speech and swallowing that these prostheses offer. Less fortunate patients who have mandibular bony or soft tissue contours that wall not support a mandibular prosthesis may still be candidates for a palatal augmentation prosthesis with anterior dentition. The augmentation will establish the vertical dimension against the residual or reconstructed tongue for enhanced swallowing and speech, and the anterior teeth will assist in airflow during speech.

Prosthodontic success in the mandibular resection patient is closely allied with the surgical reconstruction. The MVFF has revolutionized reconstruction of the mandible and contiguous oral soft tissues. The maintenance of facial form, prevention of collapse of the oral cavity, and tethering of intraoral tissues have greatly enhanced the results obtained by prosthodontic intervention.

Implant Rehabilitation of the Mandible Compromised by Radiotherapy

o Jeffrey E. Rubenstein, DMD, MS

Oral rehabilitation of patients whose mandibles and/or adjacent structures arc treated with surgery and radiotherapy presents the maxillofacial prosthodontist with a variety of challenges relative to their treatment with the use of os- seointegration. At the time of the diagnosis of cancer, patients can be grouped into three broad categories: the dentate patient with intact or partially intact dentition and reasonable periodontal health; the dentate patient with moderate to severe periodontal compromise and/or decayed, missing, or questionable teeth; and the edentulous patient.

Following treatment for oral cancer, these patients present with mandibles that require prosthodontic rehabilitation of either partial or full-arch edentulism. In the past, many of these patients typically presented with discontinuity defects that necessitated creative prosthodontic management of their discordant occlusal relationships and mandibular movements based on the one remaining condyle and associated musculature. These jaw movements were further compromised by scarring and radiation fibrosis to varying degrees. Additionally, the soft tissue contours intraorallv were frequently compromised by the need to achieve primary closure of the surgical site. This often created obliteration of the sulcus and limited range of motion of the tongue. Posttreatment sequelae of radiotherapy often left the oral tissues less than ideal for soft tissue support. Not uncommonly, trismus, fibrosis, and xerostomia further complicated access to the oral cavity for making impressions, for the patients to conveniently place and remove their prostheses, and for eating a normal diet.

With the introduction of nonvascularized and vascularized bone-graft reconstruction, restoration of mandibular continuity has made a major step forward in the rehabilitation of these patients. However, the state of the art still leaves these reconstructed mandibles as significant prosthodontic rehabilitation challenges. Restored continuity of the mandible in and of itself does not create an ideal field onto which conventional removable prosthodontic rehabilitation can routinely be fabricated to successfully restore oral function. Restoration of mandibular continuity via bone grafting either vascularized (ie, fibula, scapula, or iliac microvascular grafting) or nonvascularized (iliac crest) grafts do not necessarily restore normal soft tissue and bony architecture needed to accomplish adequate conventional (tissue-borne) prosthodontic treatment. Furthermore, radiotherapy used in combination with the reconstructed mandible creates an uncertain risk of possible graft compromise if removable prostheses load these tissues unfavorably.

The application of osseointegrated implants has offered a major improvement in the ability to manage these complex rehabilitative challenges. By providing a foundation onto which fixed prosthodontic treatment is based or for retention of removable prosthescs, implants serve a useful and important role in making rehabilitative efforts functional rather than ornamental. Since the majority of treatment experience gained to date at the Maxillofacial Clinic of the University of Washington School of Dentistry has been with edentulous patients who have been treated with surgery and/or radiation of the mandible or adjacent structures, the following treatment scheme focuses on mandibular full-arch fixed-implant prosthodontic rehabilitation.

Treatment Sequence

As with any treatment regime, a logical plan of action is critical. With implant treatment in particular, attention to detail and consistency in performing the required treatment procedures are prerequisite to success. The following treatment sequence has evolved over the last 10 years in the management of this patient cohort.

1. Pre-cancer surgery/radiotherapy—consultation/diagnosis records
2. Post-cancer treatment consultation
3. Diagnostic articulation
4. Preimplant hyperbaric oxygen
3. Fabrication of treatment prostheses/surgical stents
6. Phase I implant surgery
7. Postimplant hyperbaric oxygen
8. Placement/modification of treatment pros- rheses
9. Monitoring of patient between phase I/II
10. Phase II surgery
11. Prosthesis modification
12. Preliminary impression
13. Final impression
14. Maxillomandibular relationship records
15. Tooth arrangement
16. Framework fabrication/fitting
17. Tooth arrangement
18. Prosthesis placement
19. Follow-up/maintenance

With the treatment of any head and neck cancer patient for whom prosthodontic rehabilitation is anticipated, it is helpful for the members of the rehabilitation team (usually the maxillofacial surgeon and prosthodontist) to meet jointly with the patient. This joint consultation has proven to be very valuable for practitioners and patients alike. Coordination of effort, sequencing of treatment, and providing the patient with options to consider are better accomplished if done jointly rather than independently. Pretreatment dental records including mounted diagnostic study casts, a panoramic radiograph and/or full-mouth periapical radiographic series, and facial/intraoral photographs are the basics needed for adequate pretreatment documentation.

The primary goal of this consultation and diagnostic workup is twofold. It allows the treatment team to begin planning and coordinating their individual efforts into a logical treatment sequence. Second , it gives the patient a sense of the treatment possibilities so an informed decision about treatment options can be made.

Frequently, the newly diagnosed cancer patient is in a disoriented and emotional state. It may be helpful to have family members present so information can be assimilated and questions aired prior to entering into treatment. The goal of the rehabilitation team at this pretherapv juncture is to send the message to the patient and family that there is hope and that efforts will be made to restore the patient to as normal appearance and function as possible.

Evaluation of the patient’s existing prosthescs, remaining dentition, and dental history provides important diagnostic criteria to assist in treatment-planning decisions. Input regarding the management of the patient’s remaining dentition, especially when radiotherapy is an anticipated part of treatment, is best introduced prior to surgical or radiotherapeutic treatment of the tumor. If radiation treatment alone is planned, restoration of the dentition and periodontium to a reasonable state of repair and health or complete removal of the remaining hopeless teeth and an adequate healing time prior to beginning radiotherapy (at least 10 days) is strongly advised. Also, custom-fitted fluoride trays and daily appli cation of cither 0.4% stannous fluoride or 1% sodium fluoride gel are mandatory parts of the dentate patient's management for the prevention of postradiation caries. Chapter 3 reviews the management of head and neck radiation patients in detail.

Posttumor Treatment Considerations

Once tumor resection, grafting, and/or radiotherapy have been completed, the patient must be reassessed for the functional rehabilitation of the oral cavity. If the patient was edentulous prior to entering into treatment or if the remaining dentition was sacrificed as part of overall tumor management, a conventional tissue-borne prosthesis can be attempted to assess whether the patient can function adequately. Typically, a patient who has had a graft to restore mandibular continuity is not a good candidate for tissue-borne prostheses. A review of posttumor prosthodontic treatment considerations is presented in Chapter 11.

The timing of prosthodontic treatment is based on the patient's clinical presentation. Healing and recuperation following surgery and radiation are highly variable, and a range of treatment options exists for these patients. Obtaining operative reports and radiation treatment records are essential adjuncts to clinical assessment to assist in the timing of prosthodontic rehabilitation. Generally speaking, a minimum of 3 to 4 months should pass before beginning treatment with conventional tissue-borne prostheses (nonimplant). Assessment of the patient shortly after conclusion of treatment is useful in gauging the progress of healing at subsequent visits. Patients typically are anxious to begin rehabilitation and want to know when they will get their "teeth." In the past it has been advocated that a year or more pass to ensure the patient is free of disease before beginning oral rehabilitation. This philosophy has given way to starting earlier rather than later. If for no other reason, oral rehabilitation is as much part of a patient's psychological management as it is functional rehabilitation. While it is certainly prudent to ascertain the prognosis of the patient prior to commencing rehabilitation, experience has shown that predicting long-term prognosis is not a criterion for the timing of rehabilitation. Obviously, patients with known active or residual disease are not candidates for comprehensive oral rehabilitation. But patients who have undergone surgery, postoperative radiation, and graft reconstruction have been treated to cure their cancer. Withholding rehabilitation for inordinately long time intervals is inappropriate and incongruous with the focus of primary cancer management.

The diagnostic tools needed to assess the prosthodontic treatment options for patients once beyond cancer treatment include new mounted diagnostic casts; a posttreatment panoramic radiograph; if edentulous, an occlusal film of the anterior mandible; and a lateral cephalometric film. Other helpful diagnostic tools such as tomograms, or CT scans, can be useful and arc sometimes used to augment the more routinely available diagnostic tools. Individual consideration is given to these more advanced diagnostic procedures if inadequate information is obtained from the standard workup and should be requested by the implant surgeon.

A thorough clinical examination with particular attention to the contours of the remaining soft tissues and ridge form as well as the range of motion of the tongue, the degree of xerostomia, the oral opening, the neurologic integrity of sensation (of the lips in particular), and muscle function needs to be performed. Loss of oral competency and compromise of speech, swallowing, and mandibular movement all need to be considered in the overall treatment plan and management.

Preimplant Treatment Prostheses

Fabrication of treatment prostheses is an integral part of the diagnostic workup prior to implant placement. Three important diagnostic criteria can be evaluated:

1. Treating the patient with conventional prostheses will assist the clinician in determining specific issues related to arch form, vertical di-

mcnsion, centric relation, lip support, speech, swallowing, tissue tolerance, and a host of other factors.
2. The patient can assess whether or not adequate function can be achieved with a nonimplant approach to treatment.
3. If function is not satisfactory, the mandibular prosthesis can be duplicated in clear acrylic to generate a surgical stent that guides the surgeon when placing implants in an orientation and distribution that will complement rather than conflict with prosthesis design.

While not the focus of this chapter, it should be noted that the mandible cannot be treated in isolation, and the opposing arch needs to be considered part of the comprehensive management of this rehabilitation effort. Not infrequently, the maxillary arch has also been compromised during tumor management, resulting anywhere from normal complete natural dentition to a compromised base of support for a maxillary denture or a maxillary defect requiring obturation. Commensurate with these considerations, patients not able to wear a conventional maxillary denture or, if needed, an obturator, can also be considered for implant therapy in the maxilla as well as in the mandible.

Preimplant and Postimplant Hyperbaric Oxygen Treatment

Currently, two camps exist regarding the placement of implants in a radiated mandible. One advocates treatment of these patients with adjunctive hyperbaric oxygen treatment (Larsen, 1997) and the other does not advocate its use (Keller, 1997). The literature seems to suggest an equivalent success rate of osseointegration for radiated patients treated with or without hyperbaric oxygen. However, it should be emphasized that these reports represent data based on a relatively small number of patients, most of whom have not been followed for long periods. Further, many of the patients in these studies received radiation to fields that did not involve the anterior mandible, where implants are generally placed in an edentulous situation. Much still needs to be learned about the efficacy and safety of implant therapy for the mandible treated with radiotherapy. The Maxillofacial Clinic at the University of Washington advocates the use of adjunctive preimplant and postimplant hyperbaric oxygen therapy as part of the treatment protocol. This treatment consists of 20 preimplant surgery hyperbaric treatments and 10 postimplant surgery treatments. Each treatment consists of breathing pressurized oxygen at 2.4 atm for 90 minutes as advocated by the Marx protocol (Marx and Ames, 1982)'.

Surgical Stents

Implant placement should not take place without a presurgical prosthodontic workup and, in general, fabrication of a surgical stent. Fabrication of treatment prostheses prior to phase 1 implant surgery is the best way to determine, control, and plan for implant placement in this patient group in particular.

A variety' of methods have been used to fabricate surgical stents. One method commonly used is to make an overextended intraoral alginate impression of either the wax trial setup or the completed treatment prosthesis in place. The recovered impression containing the denture setup or treatment denture is then poured in dental stone. If undercuts exist in the denture-bearing area, they can be blocked out prior to pouring the impression. The land area should be made broad and smooth to avoid locking the edge of the tray in the stone. Once set, the impression is recovered and the denture removed from the impression with a blast of air. The impression then becomes the top half of the flask and the cast the bottom half (Fig 13-1). Tin-foil substitute is applied to the cast and a loose mix of clear au- topolvmerizing resin is poured or injected into the impression and over the ridge on the cast. The impression is then reseated on the cast and a rubber band is used to secure them together (Fig
13- 2). The assembled impression/cast is placed in a pressure pot at 15 psi and left to polymerize for 10 minutes. The stent is recovered from the

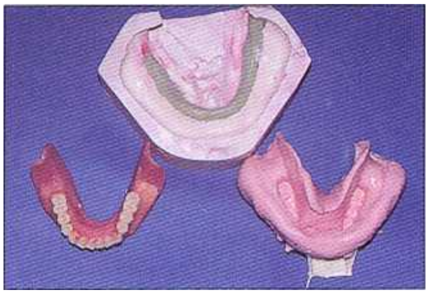


Fig 13-1 Surgical stent fabrication using an intraoral alginate impression in a disposable stock plastic tray. The impression is poured by injecting automixed poly- vinylsiloxane into ridge and undercut areas which is then backed by stone. The impression is separated and the trial wax setup or completed mandibular denture is removed with a blast of air. The impression becomes the top half of the flask and the cast the bottom half to generate a clear acrylic replica of the mandibular denture.

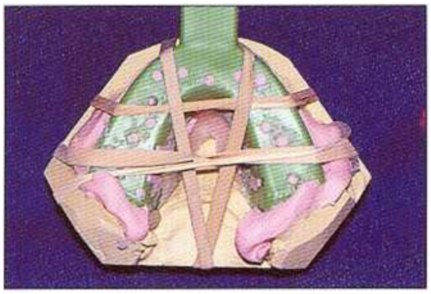


Fig 13-2 After the impression is filled and the cast is covered with a loose mix of autopolymerizing clear acrylic resin, the two flask halves are assembled, held together with rubber bands, and placed in a pressure pot at 15 psi for 10 minutes.

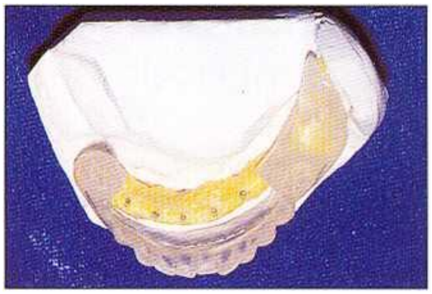


Fig 13-3 An example of a completed surgical stent for a patient who underwent iliac crest graft reconstruction of the right posterior body of the mandible. The stent is cut back on its lingual aspect to expose the ridge crest and relate the anticipated tooth position to the intended implant placement sites. Note the reinforcing wire embedded in the stent to strengthen and minimize warping of the stent once it has been cut back.

impression/cast flask and evaluated. If bubbles exist, they can be corrected with salt and pepper technique (powder and liquid clear resin) to fill them in.

A trough is cut into the buccal/labial surface at the gingival margin and a heavy-gauge half- round wire (12 gauge, Austenal, Chicago, IL) is contoured and embedded into the stent with clear autopolymerizing resin. The lingual surface of the stent is cut back from the mesial aspect of the left to the right first molars, eliminating the lingual flange in this region, leaving the anterior incisal edge and posterior buccal contours intact, and creating a zone for suggested implant placement (Fig 13-3).

Surgical stents should be thoroughly polished to eliminate rough edges, cleaned, rinsed, and packaged in cold sterilization 24 hours prior to the scheduled surgery. If desired, ethylene oxide gas sterilization can be used. It is also useful to return the stent to the prosthodontist following phase I surgery. When the implants have been uncovered, the stent will serve as a record of the surgeon's effort to comply with the prescription for implant placement.

Phase I Surgery

Because the focus of this chapter is on prostho- dontic management, the surgical phase is not covered in detail here. It is helpful for the prosthodontist to attend the implant placement surgery and offer suggestions relative to angulation, number of implants, and distribution when possible. This is particularly important when issues are identified that require compromise at surgery. For example, graft reconstruction often leaves the fixation plate in place, demanding decisions as to which horizontal fixation screws need to be removed to facilitate implant placement, which can also impact implant distribution. Another situation is the need to angle implants due to unfavorable bone contours that may not have been apparent during radiographic and clinical assessment. For the prosthodontist to see where surgical compromises need to be made and to have input at the time of implant placement are often valuable sources of information for the surgeon and assist in the development of mutual understanding of the treatment needs as well as for maximum patient benefit.

Placement and Modification of Treatment Prostheses

Patients typically object when they cannot wear their prostheses. It is important to make the patient aware of the risks involved in wearing a prosthesis too soon after implant surgery. This information should be made available to the patient prior to entering into treatment as part of comprehensive informed consent. Early loading of the overlying tissues should be avoided, particularly in the patient who has had radiation treatment. A minimum of 1 week is generally the interval that a nonradiated edentulous patient waits before using the mandibular prosthesis. For the radiated patient, this interval should conservatively be doubled, but this too must be judged on an individual basis. When placed, the denture needs to be appropriately modified to provide 3 to 5 mm of cushion over the implant sites. Typically, Lvnal (Dentsply, Milford, DE) is used to satisfy this requirement. The denture base needs to be cut back liberally prior to the reline procedure. It is also advisable to shorten the buccal and lingual flanges 2 to 3 mm as well. The denture base is moistened with monomer prior to the application of the Lynal to promote a good bond between the hard and resilient material. It is generally desirable to have the denture base contact the residual ridge distal to the mental foramina with hard resin rather than Lynal. This limits the loading of the tissues so that occlusal loading bottoms out in the molar area with the hard resin contacting the residual ridge before the resilient material gets excessively loaded over the implant sites. Tissue health and the condition of the resilient liner should be monitored every 4 to 6 weeks following implant placement.

In cases where minimum interocclusal distance exists, the removal of a significant volume of denture base material to accomplish the reline procedure puts the denture at risk for fracture. In this case, the lingual aspect of the denture can be reinforced with wire (braided ligature or half- round), a prefabricated lingual bar, or fiber reinforcing materials. For clenching or bruxing patients, it is suggested to reinforce the denture base prophylactically rather than to repair a fractured denture on an emergency basis.

Abutment Connection Surgery

Although some clinicians prefer to have healing abutments placed, wait for the soft tissues to mature, and then select transmucosal abutments with the appropriate height for each site, the surgeon can frequently select the appropriate abutments at the time of uncovering. Generally, the abutment collar should extend at least 2 mm above the tissue level. In radiated patients or patients with bone grafts, it is preferable to err on the side of too tall rather than too close to the tissue level, particularly if the periabutment tissue is not mucosa but imported soft tissue from elsewhere, such as skin. While attached tissue is not an absolute requirement to maintain soft tissue health around implant abutments, it is especially helpful in grafted cases to try to achieve a zone of attached tissue when possible.

Occasionally, the tissue overlying the implants is very thin and a biopsy core punch can be used to uncover them. When the implant sites arc not easily appreciated, a full-thickness flap must be raised. At times a vestibuloplasty with or without skin grafting is needed as part of phase II surgery. In these more involved soft tissue procedures, it is usually advisable to place standard abutments with large healing caps to assist in retaining a surgical dressing that will apply pressure to the flap during healing. Several pack changes may be required.

Prosthesis Modification

Once adequate tissue healing has occurred, the treatment denture can once again be modified to fit over the abutments. If five implants have been placed in the anterior mandible, alternating large and small healing caps typically provide excellent retention of the treatment prosthesis when Lynal is used to engage the undercuts created by the overhang of the large caps.

The provision of a retentive, stable treatment prosthesis is a very important procedure. For many patients, this is the first time they have enjoyed functional capability since before their cancer operation. The provision of a retentive and functional treatment prosthesis is possibly the most rewarding aspect of treatment, making the final prosthesis seem anticlimactic. Taking the time to create a retentive prosthesis at this juncture is time well spent and will enhance the doctor-patient relationship and make the treatment to come more manageable for both parties.

There are occasions when this period of a treatment prosthesis retained by healing caps may need to be modified. One such instance is the case with minimal interocclusal space where the long-range treatment of necessity will need to be fabricated at implant level rather than abutment level. In this instance, two options exist: leaving the patient with the treatment denture relined over the healing abutments or converting the mandibular treatment denture into a provisional fixed-detachable implant-supported prosthesis.

Preliminary Impression

What follows is a description of the protocol for fabrication of an implant-supported mandibular prosthesis based on four to six implants placed in the anterior mandible. Typically, the preliminary impression is made about 1 week after implant surgery or at about the time of suture removal. If the tissue doesn't appear well enough healed it is advisable to defer making the preliminary impression for 1 more week. The impression is made with alginate using stock metal distal extension base frays. Healing caps are removed from the transmucosal abutments, and tapered impression copings (DCA 080, Nobel Biocare, Yorba Linda, CA) are placed prior to making the impression. If the impression is made at implant level, the tapered two-piece impression coping is used with the nonslotted top fixation pin (DCA 448). When recovered, the impression copings are removed and abutment (DCA 015) or implant replicas (DCD 084) are placed, after which the copings are reinserted into the impression. If at abutment level, type 3 dental stone is used for the preliminary cast. If at implant level, the impression must have a soft tissue cast developed first before pouring stone into the impression. Many materials are available for soft tissue casts. Tru- soft (Bosworth, Skokie, IL), a resilient denture reline material, is a convenient material for this purpose. It can be applied to the impression by- injecting a loose mix of the material with a small syringe or applied with a bush using a salt and pepper technique. Once set, the material is coated with a separator before vibrating stone into the impression. The soft tissue cast is then removable or replaceable on the cast.

The recovered preliminary cast with abutment or implant replicas in place provides more useful information than just recording and making a cast of the healing caps or healing abutments. With the analogues in the preliminary cast, a controlled approach for the master impression can be facilitated. The preliminary impression copings are removed and the square final abutment-level impression copings (DCC 026; if at implant level, DCA 099) are placed on the cast. With these in place, one can design the height of the open-top impression tray and plan for uniform relief of the tray around the abutment sites. Outline of the border extensions is done by the prosthodontist before tray fabrication. Wax relief with ridge-crest tissue stops posterior to the implant sites is developed with single-thickness baseplate wax relief over the residual ridges.

Triad clear tray material (Dentsplv, Milford, DE) is used to interconnect the impression copings. This block of material is light polymerized. A layer of tin foil is applied over the Triad block/impression copings and then a doublethickness layer of baseplate wax is applied over the foil. Triad tray material is then applied over the wax relief and trimmed to the border outline on the cast.

Bite blocks of Triad tray material are formed over residual ridge areas of the tray distal to the implant sites, and the open-well area around the implant sites is made thicker at the top of the well, leaving the flange area single thickness. Once so formed, the Triad material is light polymerized, recovered, and trimmed to the desired border extensions. The wax blockout is eliminated from the tray and cast. The blocks are sec-

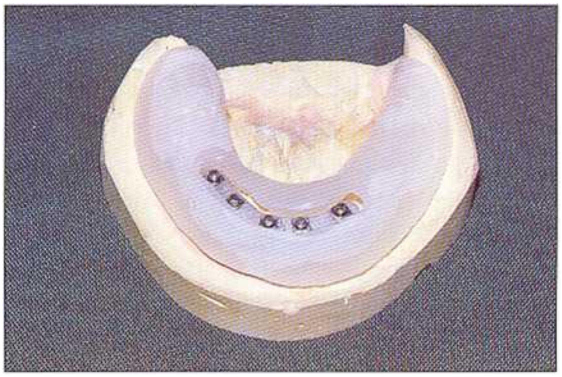


Fig 13-4 Completed final impression tray and Triad blocks incorporated on the square impression copings ready for an abutment-level impression. It is critical for the final impression tray to be rigid to minimize distortion during the impression phase and master-cast fabrication phase of treatment.

tioned with a two-sided thin diamond disc (918PB220, Brasseler, Savannah, GA) between each abutment pair, creating individual blocks for each implant site, and the blocks are numbered for correct repositioning. The tray and blocks arc now complete and ready for the final impression appointment (Fig 13-4).

Final Impression

Because of space limitations, only the abutment- level technique will be described here. The final impression is not recorded until about a month after phase II surgery. This interval is adjusted based on the clinical assessment of the maturation of the tissue and is dependent upon the extent of surgery required to accomplish phase II surgery. For abutment-level final impressions, the healing caps are removed and the abutment screws are released and retightened using an electric torque driver (Nobel Biocare). Three repetitions at 20 Ncm of preload are applied at each site. Verification of the hex head abutment-implant interface should be made with a radiograph (panoramic, periapical, or mini lateral jaw using occlusal films) prior to making the final impression. The impression coping/triad blocks are secured and aligned on each abutment site and torqued to 10 Ncm with the electric torque driver (Fig 13-5). An amalgam matrix band is placed between each pair of blocks during this process to maintain a uniform spacing. Once complete or, if preferred, before placing the blocks, the custom tray is evaluated for extension and adjusted as needed.

The blocks are splinted with a heavy-viscosity light-activated resin (Palavit, Kulzer, Irvine, CA) (Fig 13-6). The custom tray is then tried in, and if it seats without binding, it is removed and a layer of baseplate wax is warmed and adapted over the open top of the tray. The wax is tempered in a water bath (140°F) and then seated in- traorally to adapt the wax to the top of the guide pins imprinting their tops into the wax. The tray is then removed, dried, and coated with Impregum (Premier, Seefeld, Germany) adhesive. While the adhesive is drying, the patient’s lips are coated with petrolatum and the tissues are irrigated and suctioned. Impregum impression material is dispensed into a syringe and into the tray with the Automix delivery system (Premier). The impression material is injected beneath the indexed Triad blocks and into the buccal and lingual suleis of the anterior mandible. The impression tray is then seated such that the guide pins bottom out on the underside of the wax lid. The patient is asked to project the tongue and move it laterally to the left and right. The lips and cheeks are used to border-mold the impression material following seating of the tray. When set, the wax lid is removed, the guide pins loosened

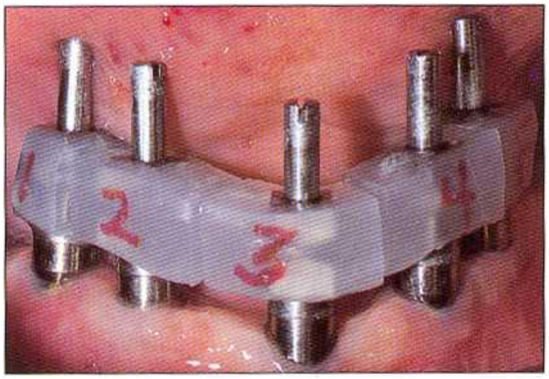


Fig 13-5 Triad block/square impression copings in place intraorally before indexing.The abutment screws are first released and retightened to 20 Ncm with an electric torque driver prior to placing the impression copings. The impression copings are secured with 10 Ncm of preload, and verification of a gap between sites is assessed using an amalgam matrix band prior to splinting.

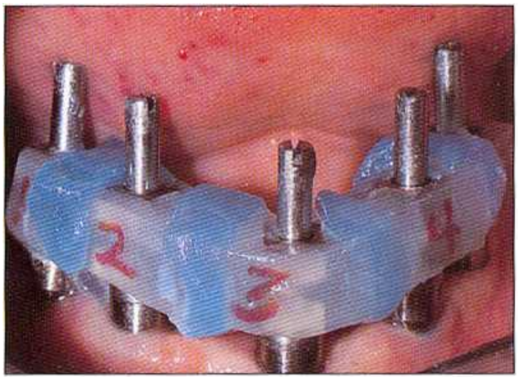


Fig 13-6 Completed index of the blocks with each joint reinforced with heavy viscosity Palavit (K2). The final impression tray should be tried in at this point to ensure that it will seat over the splinted blocks without binding. The wax lid should then be adapted over the open top part of the tray and the top of the guide pins indexed into the underside of the wax lid prior to making the impression.

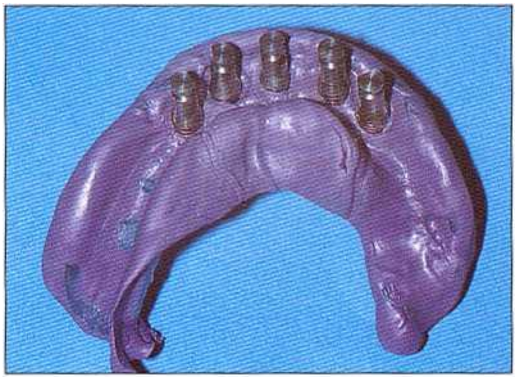


Fig 13-7 Recovered Impregum final impression for a patient who had a coronal resection and partial glossectomy in the left retromylohyoid region. This impression was recorded at the implant level. Implant-level replicas are secured to the splinted implant-level impression copings and torqued to 10 Ncm prior to boxing and pouring the impression with vacuum-mixed type IV dental stone.

completely, and the impression is removed (Fig 13-7). The abutment screws should be checked to confirm that they have not loosened. The healing caps are replaced and the patient scheduled for a return appointment.

The impression is examined to check the fit surface of the impression copings to verify that no flash of impression material exists. If flash is discovered, the impression should be repeated because it indicates incomplete seating of the impression coping(s) or perhaps inaccurate machining of the fitting surfaces. Abutment replicas are secured to each impression coping and torqued to 10 Ncm while countertorquing the abutment replica with an abutment clamp. The impression is then boxed and poured with low- expansion vacuum-mixed die stone.

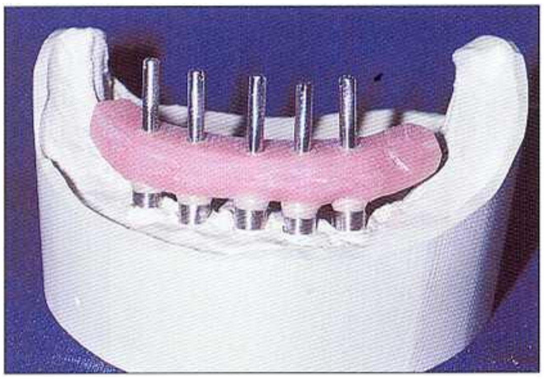


Fig 13-8 Triad record base is fabricated using temporary cylinders that first have Duralay applied to the retentive ribbing to strengthen the bond between the Triad and the temporary cylinder. The lingual aspect of the record base can be reinforced with a heavy-gauge half-round wire to strengthen the record base prior to setting teeth. As the base gets cut back to accommodate tooth position, the strength of the base may be compromised, which can result in base fracture.

Maxillomandibular Relationship Records

A stable record base for the mandibular arch is necessary to accurately establish and make a centric relation record. The technique advocated for record base fabrication is to incorporate temporary cylinders (DCA 159-0) into a Triad tray material strut running from 15 mm posterior to the last implant site and interconnecting the temporary cylinders. This bar of Triad once formed, polymerized, and reinforced lingually with a braided or half-round wire, if desired, will serve as a good foundation onto which a wax rim can be placed (Fig 13-8). Using 20-mm guide pins (DCA 098) to maintain the screw access holes while fashioning the wax rim is helpful. Once the rim is contoured, it is also helpful to remove all the guide pins and place cotton pellets and/or inject petrolatum into all but the most medial site. In this site, a slotted gold screw (DCA-075-0) is used to attach the rim as it is altered to conform with creation of the desired lip support and vertical dimension of occlusion.

Once the face-bow mounting is completed, centric relation is recorded. A wide array of materials can be used to record centric relation, including aluwax, impression plaster, zinc oxide and eugenol bite registration pastes, polyvinyl- siloxane, and polyethers to name a few. A semi- adjustable articulator is adequate for this type of treatment.

Tooth Arrangement

Making a mandibular treatment denture prior to implant placement ideally works out issues of denture esthetics, tooth shape, shade, position, arch form, lip support, and phonetics. At this juncture, assuming the maxillary denture fabricated prior to implant placement is satisfactory to the patient, one can concentrate on orienting the mandibular teeth on the record base. This tooth arrangement serves several useful functions. It gives the patient a preview of what the completed prosthesis will look and feel like as compared with the treatment denture, and it gives the clinician an opportunity to evaluate the soft tissue relationships, lip support, tongue space, vertical dimension, and centric relation.

A mutual agreement between the patient and the prosthodontist must be resolved as to the adequacy of the setup. It should be emphasized to the patient at this stage of development that the tooth arrangement represents a blueprint for the final result. Therefore, the relative position of the teeth must be deemed acceptable by the patient before next steps can be taken. Minor changes of tooth position can occur, but major movement labially or lingually will result in either a bulky prosthesis or a weakened framework that could cause postinsert-ion complications.

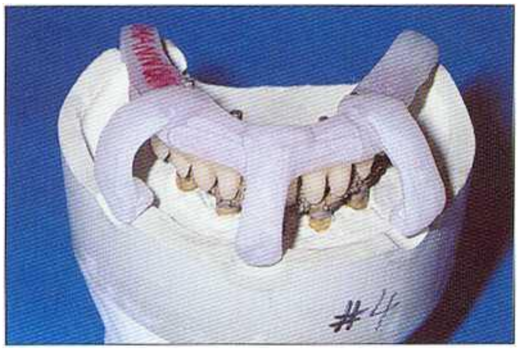


Fig 13-9 Spider matrix assists in maintaining the tooth-implant relationship on the master cast. Flere the spider is incompletely seated on the master cast to denote the notches made in the land area of the master cast that relate the position of the spider to the cast.

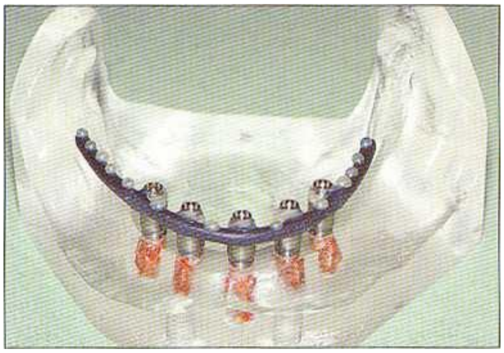


Fig 13-10 Developing the waxup of the framework begins with securing the gold cylinders to the abutment replicas with 10 Ncm of preload using an electric torque driver. The groove around each cylinder is filled with Duralay and then small extensions are placed mesiodistally. A wax sprue wire is placed horizontally to extend to the anticipated cantilever length.

Framework Fabrication and Fitting

Framework design and fabrication techniques vary widely. The technique described here represents treatment of hundreds of edentulous patients over the last 15 years. When the tooth arrangement has been established, it is necessary to record tooth position and relate it to the master cast so the tooth/implant position can be studied. A variety of matrices have been used but one of the easiest and most convenient to work with is the spider matrix. To fabricate this matrix, several notches are made on the land area of the master cast. A clear Triad index is made of the occlusal/incisal edges of the tooth arrangement, and struts from this index are extended buccallv, labially, and to the retromolar pad notches on the land area with clear Triad (Fig 13-9). This is light polymerized, recovered, trimmed, and refit to the setup to verify accurate seating. The teeth are removed from the master cast, placed into the spider, and secured with sticky wax. Gold cylinders (DCA 072-0) are anchored in place on each abutment analogue by guide pins secured to 10 Ncm with an electric torque driver. Duralay (Reliance, Worth, IL) is applied to the circumferential recess of each gold cylinder with a powder and liquid brush technique. Small (mouse ear) extensions of Duralay are placed mcsially and dis- tally. Duralay is preferred because wax applied to the gold cylinders docs not stick well and could result in distortion or change in cylinder orientation when casting. The spider is then replaced on the master cast and the buccolingual and inferior/superior extents of the framework are assessed regarding tooth/implant position and available space. Sometimes it is helpful to hollow- grind the teeth to create adequate space for framework bulk. Eighteen-gauge wax sprue wire is then used to connect the cylinders and extend posteriorly to the cantilever region, creating a skeleton for the developing framework (Fig 13- 10). Vertical struts of wax sprue wire are then placed between the abutment sites and posteriorly to support another horizontal strut that skeletonizes the superior aspect of the framework. Inlay wax is then applied to the skeleton to develop the full three-dimensional contour. The bulkiest aspect of the framework is around the most distal abutment sites as this is where the highest compressive stress concentration occurs during occlusal loading. Buccal/lingual holes are cut through the waxup over each abutment site to make placement of the gold screws easier to

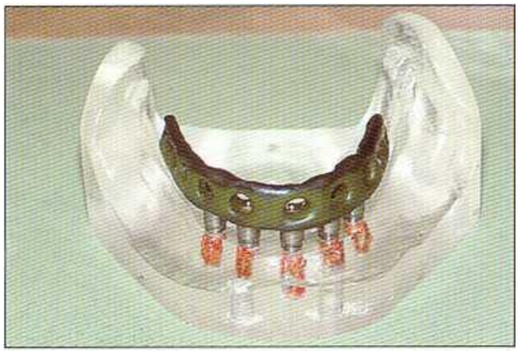


Fig 13-11 Inlay wax is applied to the sprue wire skeleton to develop a full-contour waxup of the framework.

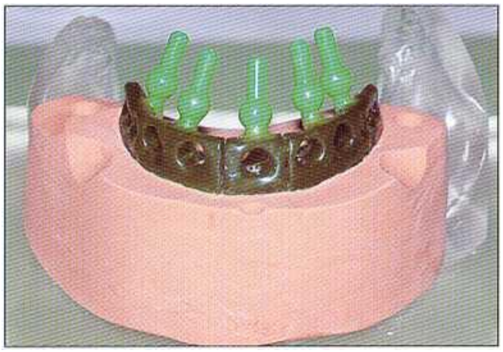
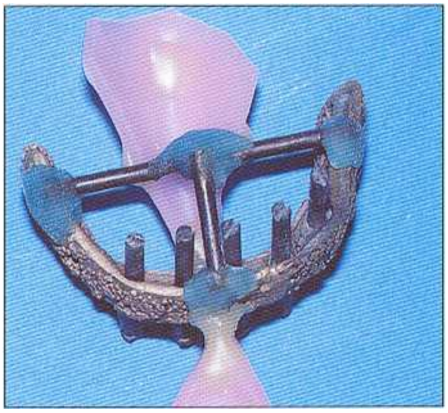


Fig 13-12 The framework is sprued with reservoir sprues using two sprues for the paired posterior segments and one for the medial single segment. Once cast, the paired segments are first evaluated for passive fit. If determined to fit, then one pair is indexed to the middle segment and soldered.

visualize during try-in, to provide for mechanical retention of the resin veneer, and to decease the amount of metal used. Smaller holes are cut through the cantilever extensions buccolingually as well (Fig 13-11). A finish line is cut into the lingual extending approximately 2 mm distal to the last abutment, then under the cantilever extension buccally, and then labial to the abutment sites. With such a design, the inferior surface in the periabutment region is left unveneered and remains a highly polished metal surface. The cantilever extension is completely surrounded by veneering resin and ends as a bullet-shaped politic design contacting the residual ridge.

When the framework is waxed to final contour, it is beaded and segmented. Adhesive is placed on the wax, and small retention beads or salt crystals are applied to the surface buccolingually, but not inferior to the finish line. The framework is then sectioned with a wax saw between abutments 2 and 3 and 3 and 4 for a five- abutment support system. The three segments, two posterior paired segments and one single median segment, are sprued with preformed plastic sprues with reservoirs (Fig 13-12). The segments are invested and cast in type IV gold alloy (Primalor G, Degussa, South Plainfield, NJ). The bench-cooled segments are divested (not sandblasted) and pickled (Prevox, Williams, Amherst, NY). Careful inspection of the fit surface of the cylinders is made to assess whether flash has migrated onto the abutment fitting surface during the casting process. If this has occurred, the segment is not used and a new cylinder is rewaxed and cast.

This approach advocates assessing the fit of the cast paired segments first, which for a five- abutment model are segments 1 and 2 and 4 and 5. Gold screws are placed into each cylinder and one site at a time is secured intraorallv to its abutment. The gold screws are each tightened and released one at a time for each paired segment while clinically assessing the interface between framework and abutment for gap formation. Vertical gaps arc attributed to distortion from the fabrication/casting process. Angular distortion can also produce vertical gaps. While it is possible to correct or eliminate the gap by forcefully tightening the screw's, this in effect results in a framework that is under strain and then subjected to occlusal loading from a number of different vectors. The loading of a misfit framework ultimately can result in component loosening, screw' or framework fracture, implant fracture, or failure of the bone-implant interface. The importance of achieving *passive fit*-cannot be overemphasized. The dilemma is that passive fit is a term seeking a definition with no good parameters available to guide the clinician as to what a “clinically acceptable” fit is.



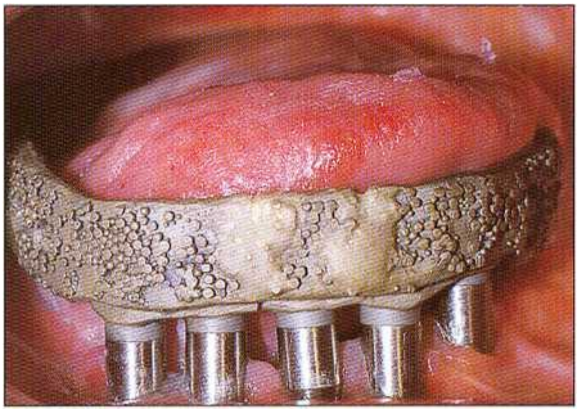


Fig 13-13 Full framework indexed with **Fig 13-14** Soldered framework is tried in to clinically Palavit and reinforced with cross-arch sta- evaluate fit. bilization using long shank burs. The wax vent pattern is placed before solder investment to minimize manipulation of the investment prior to burnout and soldering.

If after assessing the fit of the paired segments it is determined that no observable gap formation occurs, the next step is to index one of the paired segments to the medial single segment. The oxide layer on all joint surfaces should be removed before indexing. When seating the segment, it is critical to verify that it does not bind with the other segments. If an amalgam matrix band cannot pass through the segments, they should be relieved until it can. Indexing is again done with Palavit. The index is reinforced with K2 and further splinted using a friction-grip bur on the superior labial surface. The gold screws are released and the three-unit indexed segment is removed.

Soldering analogues are then secured at each site by holding the analogue with an abutment clamp or hemostat and then torquing the guide pin to 10 Ncm, taking care not to distort the index. A bead of sticky wax is placed over the inferior aspect of the indexed joint, and triangular baseplate wax forms are luted to the sticky-wax bead, thereby creating a vent pattern. The segment is then invested in high-heat solder investment (Red Hot, Pacific Rim, Stateline, NV) using the manufacturer's instructions regarding water/powder ratio. The investment block is trimmed on a model trimmer without water spray, making the block a minimum size to avoid a heat sink during the soldering process.

The index is burned out in an oven at 1100°F, removed, and allowed to cool. It is then fluxed (Soldering Paste Flux, Mission Dental, Charleston, SC), placed back in the oven to reheat, and then transferred to a warmed tripod stand. After heating the framework segments, 650 Fine gold solder strip (Degussa, South Plainfield, NJ) is placed on the lingual aspect of the joint space, and a gas-air torch directed from the labial is used to get the solder to flow into and fill the joint space. The assembled segment is cooled, divested, and pickled.

The three-unit segment is once again evaluated for fit with the same screw tightening/loosening/observation-for-gap protocol. If determined to fit, the remaining paired segment is indexed as previously described, with the addition of reinforcement of the index with cross-arch bur reinforcement (Fig 13-13). After investing, burning out, fluxing, soldering, divesting, and pickling, the fully assembled framework may be evaluated for fit (Fig 13-14).

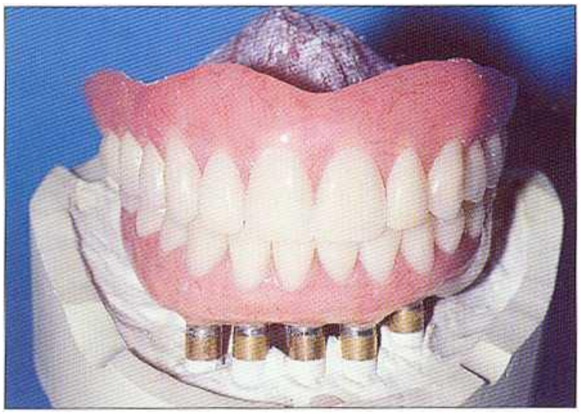


Fig 13-15 Completed maxillary denture and mandibular implant-supported prosthesis prior to clinical remount on the day of prosthesis placement.

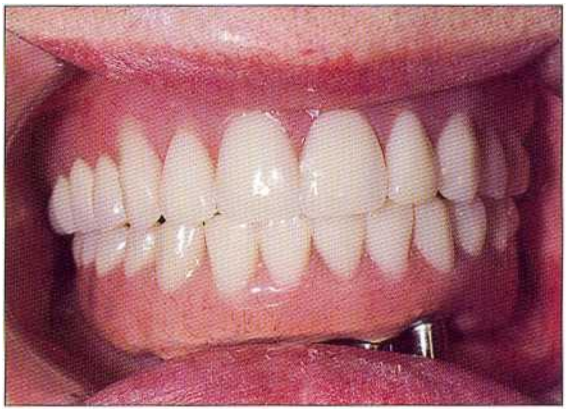


Fig 13-16 Completed prosthesis in place intraorally 2 years posttreatment. Al-though there is some residual difficulty with swallowing secondary to surgical scarring and radiation fibrosis, the patient has experienced improved function and comfort following completion of treatment.

Tooth Arrangement and Processing

The teeth are reset onto the easting and the patient is given another opportunity to assess the tooth arrangement prior to processing. Centric relation and vertical dimension of occlusion are verified. Minor changes in tooth position, rotation, and tipping can be explored at this point. The patient has the opportunity to get a sense of what the completed prosthesis will look and feel like. If the patient is hesitant, schedule a second try-in appointment prior to processing.

A number of different techniques is available to veneer the framework: conventional pressure packing, pour resin technique, and injection molding. The injection technique (Success, Dentsply) is currently the technique of choice. Conventional pressure packing has also been used. While it is conceivable that excess pressure and polymerization shrinkage could distort the framework, it is unlikely (Fig 13-15).

Prosthesis Placement

After a laboratory remount to eliminate processing error, the completed prosthesis is tried in. Lingualized occlusion makes fast work of occlusal equilibration. Slight refinement of the palatal cusp tips of the opposing denture should be obtained so that shimstock is held at each occlusal tooth contact. If cantilevers are longer than 15 mm, the most posterior tooth is adjusted free of contact. A clinical remount is accomplished with a new centric relation record. Lateral excursive contacts are relieved on the palatal inclines of the maxillary buccal cusps and the buccal inclines of the mandibular buccal cusps, leaving a “mortar and pestle” centric contact that is free in lateral excursions. Protrusive contacts arc relieved to minimize the possibility of maxillary denture dislodgment.

Once the occlusion is refined, the gold screws are secured starting from the midline and alternating left to right until all screws are tightened to 10 Ncm (Fig 13-16). It is important to note that the gold screws must be periodically checked during the first year of service. Typically they are checked 1 month postinsertion and retightened.

Since the screws are made of gold alloy, they experience initial deformation when initially loaded with occlusal forces. Once retightened, assuming even occlusal contact and good clinical lit of the framework, minimal loosening should be evident when subsequently checked. The screw access holes are sealed with cotton pellets and Duraseal (Reliance). A resilient material is preferred so one must not repeatedly cut the material out of the access hole, which can lead to enlargement of the hole, scoring of the lingual surface, and damage to the teeth or fixation screw.

Following completion of prosthesis placement, a review and demonstration of hygiene aids is given. The patient should attempt to use the aids demonstrated at this appointment so suggestions can be made and advice given about what might be most effective for various parts of the prosthesis. Emphasis as to the importance of daily maintenance relative to the long-term service of the treatment should be made at the conclusion of this appointment.

Follow-up and Maintenance

With all of the above steps completed satisfactorily, the long-range survival of this treatment is more dependent upon what occurs after treatment is completed. Without adequate daily maintenance, periodic follow-up, and in-office prophylaxis, complications associated with soft tissue and or implant/bone compromise could occur. This potential for compromise cannot be overemphasized to the patient.

While criticism has been offered regarding the difficulties associated with maintenance of the nonremovable, implant-supported prosthesis, this prosthesis still offers the most logical and practical solution for patients with irradiated oral tissues. Implant overdenture therapy has been shown to foster problems as well, particularly for the irradiated patient. The ability to keep the soft tissues from being loaded with a nontissue-borne fixed prosthetic design offers a distinct advantage over the tissue-borne implant overdenture approach. For the patient who has had surgery in addition to radiation therapy, the frequent presentation of compromised ridge and sulcus forms portends soft tissue complications and/or bone exposure. The periabutment tissues overlaid by an overdenture arc prone to hyperplasia and its attendant compromise of soft tissue and bone.

Periodontal probing is of limited value, especially with the prosthesis in situ, because it is generally impossible to place the probe along the long axis of the implant. Further, it is generally inadvisable to remove a screw-retained prosthesis for hygiene appointments. Repeated loosening and retightening of the gold screws offer no advantage to their long-term survival. Once placed, the prosthesis should only be removed if there is need for repair or modification of the prosthesis, to gain access to treat soft tissue complications, or to service and/or replace compromised components (eg, broken gold or abutment screws).

Summary

A broad overview of the management of the edentulous patient who has been irradiated and orally rehabilitated with dental implants has been presented. Some of the philosophical controversies regarding treatment protocols have been offered and one protocol has been described in detail. Clearly, this chapter cannot answer every question for the uninitiated clinician; however, the material represents experience gained and refined over the past 15 years and has proven successful in oral rehabilitation treatment for patients afflicted with oral cancer and treated with surgery and/or radiation.

References

Keller K. Placement of dental implants in the irradiated mandible: A protocol without adjunctive hyperbaric oxygen.) Oral Maxillofac Surg 1997;55:972.

Larsen P. Placement of dental implants in the irradiated mandible: A protocol involving hyperbaric oxygen. J Oral Maxillofac Surg 1997;55:967.

Marx R, Ames J. The use of hyperbaric oxygen therapy in bony reconstruction of the irradiated and tissue deficient patient. J Oral Maxillofac Surg 1982;40:412.

Prosthodontic Rehabilitation Following Total and Partial Glossectomy

o Hussein S. Zaki, DDS, MSc

The primary function of the tongue is swallowing; its secondary function is speech. Both functions are complex in nature and require integrated voluntary and involuntary muscle coordination. Alteration of these functions may result from myriad conditions, including trauma, neurologic deficits, or surgical interference such as tumor removal. It is beyond the scope of this chapter to discuss in detail the etiology or pathophysiology of dysphagia or dysphonia caused by problems of the tongue. However, to rehabilitate patients with partial or total glossectomy, an understanding of the basic anatomy and neurophysiology of the tongue is essential.

Swallowing

The purpose of swallowing is to transport food from the mouth to the stomach. The three phases of swallowing are oral, pharyngeal, and esophageal, with the oral phase under voluntary neuromuscular control and the latter two phases under involuntary neuromuscular control. In the oral phase, the tongue has several functions. It aids in crushing the food against the palate, and it helps reposition the bolus against the occlusal table. The tongue mixes food with saliva and clears the buccal vestibule and floor of the mouth. Once the food bolus is prepared, the lips and checks contract, followed by tongue contractions against the hard palate. As tongue and palate contact occurs, the soft palate elevates as the tensor, levator veli palatini, and palatopharyn- geus muscles contract, drawing the velum (soft palate) superiorly and posteriorly against the nasopharyngeal wall. While a functioning oral tongue (anterior two thirds) is critical to normal function of the oral phase of deglutition, the base of the tongue (posterior one third) plays an important role in the generation of the forces that propel the bolus posteriorly and inferiorly toward the hypopharynx. Without a functioning base of the tongue, tongue to soft palate contact cannot be made. Without adequate tongue to soft palate seal, insufficient negative pressure is generated when the hvomandibular complex elevates away from the posterior pharyngeal wall during the pharyngeal phase of swallowing. As a result, bolus propulsion is significandy impaired. The oral phase of swallowing in healthy adults is completed in approximately 1 second (Blonskv et al, 1975).

The pharyngeal phase of swallowing is initiated by velopharyngeal closure to prevent reflux of the material into the posterior choana of the nose. This is followed by closure of the larynx to prevent aspiration and elevation of the larynx and hyoid bone toward the base of the tongue. These movements arc in concert with the contraction of the pharyngeal constrictors in a superior to inferior direction. Finally, relaxation of the tonically contracted tracheopharvngeus muscle allows passage of the food bolus into the esophagus. It should be noted that the first event following velopharyngeal closure is adduction of the true vocal folds. This is a primary laryngopharyngeal protective mechanism to prevent aspiration during swallowing. As the true vocal folds adduct during swallowing, a finite period of apnea must necessarily take place with each swallow. Relating deglutition to respiration, deglutition occurs most often during expiration and includes a period of apnea ranging from 0.3 to 2.5 seconds (Sellcy et al, 1994). The clinical significance of this finding is that patients with compromised lung function will develop respiratory distress as the meal progresses. This will lead to fatigue and consequent risks of laryngeal penetration and aspiration. The oral and pharyngeal phases of swallowing are physiologically and integrally related. McConnel et al (1988) described swallowing as a pressure-generation mechanism powered by a two-pump system. These two pumps are the oropharyngeal propulsion pump (OPP) and the hypopharyngeal suction pump (HSP). The significance of normal tongue mobility for normal deglutition to take place is that any condition that affects the anterior two thirds of the tongue will necessarily affect the OPP and that any problems affecting the base of the tongue will alter HSP. The esophageal phase of swallowing is under involuntary neuromuscular control. The esophagus connects the pharynx to the stomach. The upper zone of the esophagus contains striated muscles 6 to 8 cm down to integrate interiorly with the smooth muscles of the middle zone. The middle zone extends to within 4 cm of the lower esophageal sphincter. The lower zone of the esophagus contains short segments of smooth muscle terminating in the lower esophageal sphincter.

Speech

Basic laryngeal vibrations modified by fixed and mobile articulators produce speech. The tongue is a major articulator during production of all phonemes, with the exception of bilabial and labiodental sounds (Luciello et al, 1980). It modifies the shape of the oral cavity', thus changing the resonance characteristics that produce various vowels and diphthongs. The ability of the tongue to completely or partially occlude the vocal tract produces different consonant sounds.

Prosthodontic Treatment of Total Glossectomy

Tongue defects due to tumor removal can result in either total or partial glossectomy. A total glossectomy will create a large oral cavity' with loss of oral communication and pooling of saliva and liquids. These liquids can seep around the epiglottis, leading to aspiration. Surgical closure of the laryngeal opening may reduce the incidence of aspiration and aid the patient in swallowing liquids (Mitrani and Krcspi, 1988) (Fig 14-1). With present knowledge, it is impossible to recreate the original function of the mobile tongue either surgically or prosthetically. It is, however, possible to improve function and esthetics of the tongue for these patients.

The major goals in prosthodontic rehabilitation of the total glossectomy patient without surgical reconstruction arc to (Cantor et al, 1969):

1. Reduce the size of the oral cavity, which improves resonance and minimizes the degree of pooling of saliva.
2. Direct the food bolus into the oropharynx with the aid of a trough carved into the dorsum of the tongue prosthesis.
3. Protect the underlying fragile mucosa if skin flaps were not used.
4. Develop surface contact with the surrounding structures during speech and swallowing.
5. Improve appearance and psychosocial adjustment.

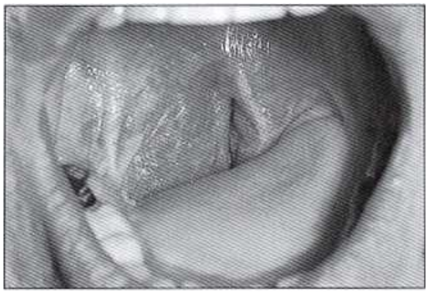


Fig 14-1 a Surgical closure of the laryngeal opening helps reduce the incidence of aspiration. The patient is saying ee.

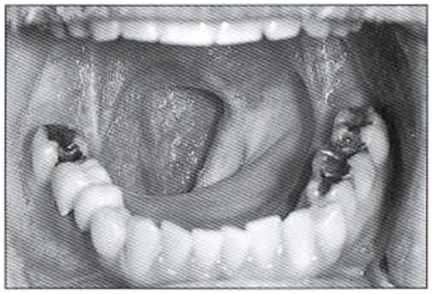


Fig 14-lb Normal pharyngeal opening at a relaxed position.

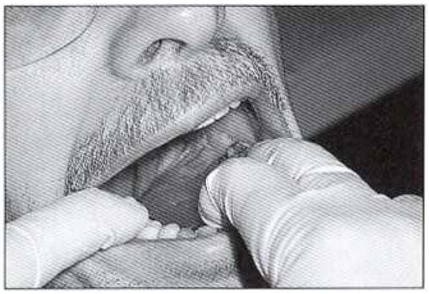


Fig 14-2 Modified plastic stock tray is tried in the patient's mouth to verify fit and comfort.

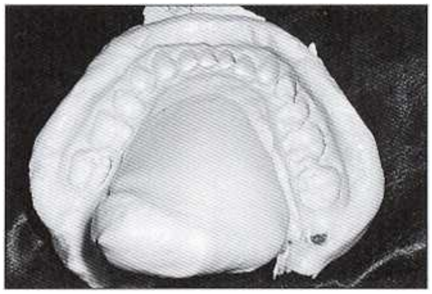


Fig 14-3 Preliminary impression of the mandible and floor of the mouth following total glossectomy.

The success of prosthodontic rehabilitation depends primarily on patient motivation, anatomic factors (such as the presence or absence of teeth), and the associated morbidity of the surrounding structures, including mandibulcctomv, palatectomy, and radiation therapy to these areas. In total glossectomy, the mandibular tongue prosthesis is the treatment of choice (Moore, 1972). However, in a situation involving an edentulous patient and an irradiated, resorbed mandibular ridge or a patient with a very mutilated dentition, a palatal augmentation prosthesis should be considered.

Construction of a Mandibular Total Tongue Prosthesis

A thorough clinical and radiographic examination should always precede the initiation of active treatment. Efforts should be made to restore carious lesions and to eradicate or bring under control all dental/periodontal disease present.

For preliminary impressions, the patient should be seated in an upright position and properly draped. It is critical for the safety of the patient to ensure that impression material does not flow into the hypopharynx. For this reason, the dental assistant must stand by with high-speed suction. A stock plastic maxillary tray of proper size should be selected. The maxillary tray is necessary to register the entire floor of the mouth. Utility wax is added to the posterior edge and the vault of the tray to confine the hydrocolloid material and to prevent it from flowing toward the patient’s throat. The modified tray should be tried in the patient’s mouth for proper fit and comfort (Fig 14-2). The tray is painted with adhesive, and quick-setting irreversible hydrocolloid is mixed. The tray is loaded and positioned intraorally. After the hydrocolloid material has set, the tray is removed, inspected, and poured in artificial stone (Fig 14-3).

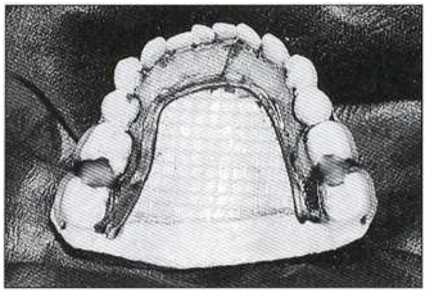
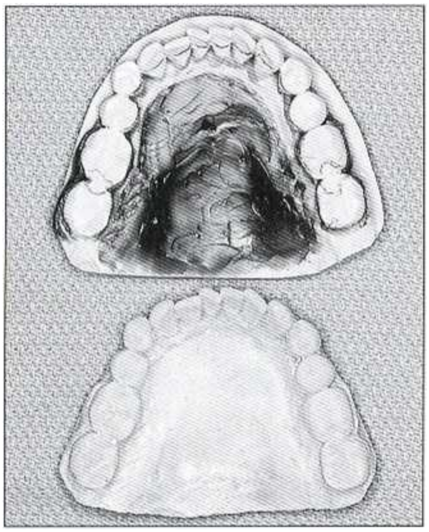


Fig 14-5a Completed wax pattern is seen on the refractory cast for construction of a mandibular total glossectomy framework.

Fig 14-4 *(below)* Master cast after block- out and the refractory cast.



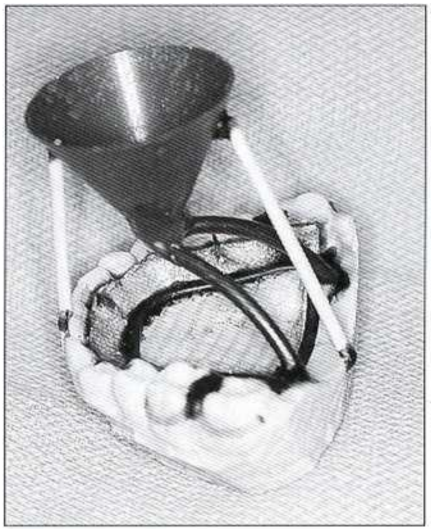
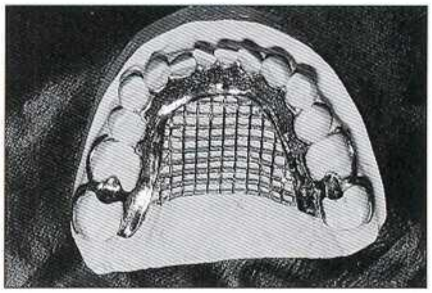


Fig 14-5b *(left)* Spruing of the total glossectomy framework.

Fig 14-5c *(below)* Finished chrome-cobalt total glossectomy framework on the master cast.



The preliminary cast is surveyed and mouth preparations in the form of occlusal rest seats and guide planes are planned. Mouth preparations are executed in the patient's mouth. The teeth are polished and the final impression is made using an impression material that is preferred by the operator and used routinely in the construction of conventional removable partial denture (RPD) frameworks. The impression is poured in improved artificial stone. All undesirable undercuts are blocked out and the area of the floor of the mouth is relieved with at least two thicknesses of baseplate wax before duplicating the master cast to the refractory cast (big 14-4).

The wax pattern of the glossectomy framework is finished, sprueci, invested, cast in chrome- cobalt alloy, and polished following conventional techniques (Fig 14-5). The framework is tried in the patient's mouth using rouge and chloroform or similar disclosing media to ensure complete and passive seating on the teeth (Fig 14-6). Care should be taken to ensure that the retentive meshwork does not touch the floor of the mouth during any functional movement. If it does, it should be cut and soldered in a more occlusal position or the framework remade at a higher level. If the operator or the patient decides that more than one tongue prosthesis would be beneficial, the metal framework can be replicated accordingly. Each framework would be used to carry a different tongue prosthesis.

A layer of sticky wax is luted to the retentive meshwork of the RPD framework. This layer of sticky wax is then covered with a layer of mouth-temperature softening wax (Iowa wax, Kerr, Romulus, MI) and then placed in the patient's mouth. The patient is asked to perform functional movements with the floor of the mouth such as attempting to pronounce various sounds like *eeee*, opening and closing, and attempting to swallow (Fig 14-7). Every 10 minutes the wax tracing is inspected and more wax is

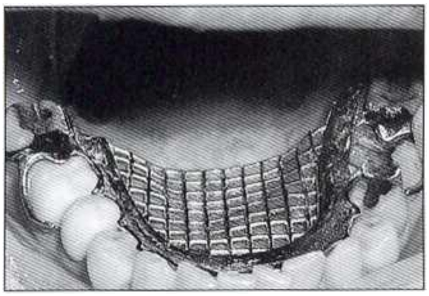


Fig 14-6 Total glossectomy framework is tried in the patient's mouth.

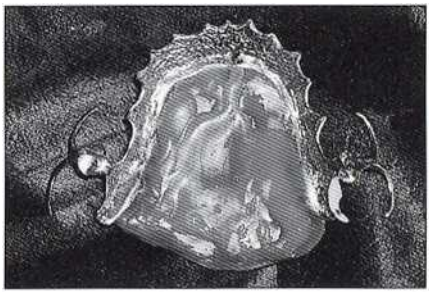


Fig 14-7a A layer of sticky wax is placed on the retentive meshwork.

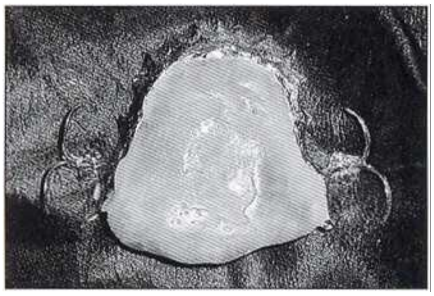
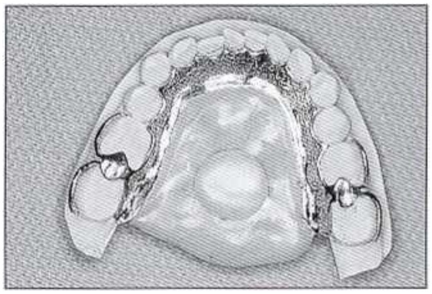


Fig 14-7b Iowa-wax impression of the floor of the mouth in glossectomy patient.



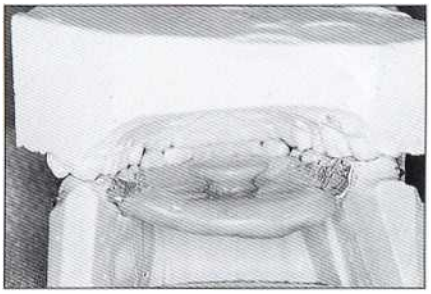


Fig 14-8a *(left)* Acrylic-resin base with a retentive mushroom extension fitted on altered master cast.

Fig 14-8b *(right)* Maxillary and mandibular casts showing that the framework and the mushroom retentive extension do not interfere with the opposing arch (palate).

added to ensure passive contact with the floor of the mouth during functional movements. After complete tracing of the floor of the mouth, the framework is invested in the cope (or base portion) of a maxillary denture flask with the wax impression facing downward into the cope. A mushroomlike projection is waxed to the oral surface of the framework to retain the oral portion of the tongue prosthesis. The operator should then complete the investment procedure and process the prosthesis in heat-cured acrylic resin. The prosthesis is then retrieved, finished, and polished (Fig 14-8). The framework with the acrylic base is then tried in the patient's mouth. A disclosing material such as pressure-indicating paste is utilized to eliminate pressure areas in the floor of the mouth.

It has been suggested that three prosthetic tongues be made: one for speech, one for swallowing, and one for both speech and swallowing (Moore, 1972; Myers and Sun, 1996). The prosthetic tongue for speech should have an anterior elevation to facilitate articulation of the anterior linguoalveolar sounds *t* and *d*. It should also have a posterior elevation to aid in the articulation of the glottal stops or posterior linguoalveolar sounds *g* and *k*. Both elevations help to shape the oral cavity, thus improving vowel production in general.

To create these elevations, gray stick compound is luted to the anterior portion of the framework and the patient is asked to occlude the teeth. Compound is then added to the posterior portion of the framework and the patient is asked again to occlude the teeth. Contact with the palate should be evident in both areas of compound. Both anterior and posterior elevations are reduced 2 to 3 mm and a layer of Iowa wax is flowed onto the surface. The patient is asked to repeat f, *d*, *kygy* and attempt swallowing. The wax surface is then examined. It should be glossy, indicating that contact with the palatal tissue has been made. If compound is showing through, it should be reduced with a sharp knife and a new layer of Iowa wax added. The patient should repeat the mandibular movements to pronounce f, d_y *ky g*. These tracings should be per-

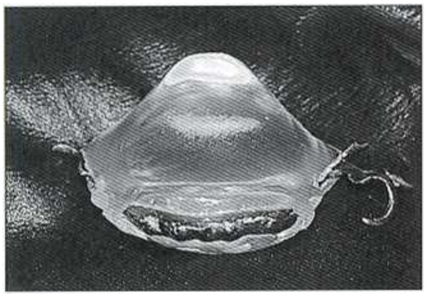


Fig 14-9a Mandibular tongue prosthesis for speech. It is made of clear acrylic resin and has anterior and posterior elevations.

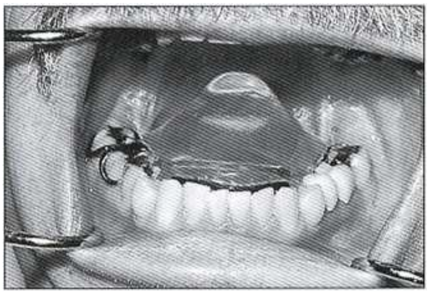


Fig 14-9b Mandibular tongue prosthesis for speech in the patient's mouth.

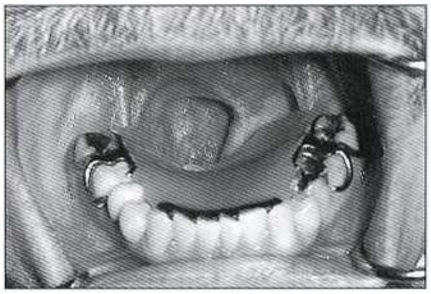


Fig 14-10 Mandibular tongue prosthesis for swallowing. It has a troughlike base in the posterior aspect.

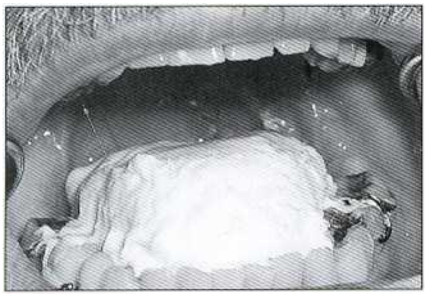


Fig 14-1 la Coe-Comfort tissue conditioning material is being used during tracing of the mandibular tongue prosthesis.

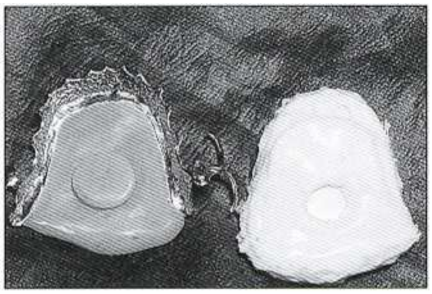


Fig 14-1 lb After final tracing, the Coe-Comfort artificial tongue is snapped off its acrylic-resin base before processing in silicone material.

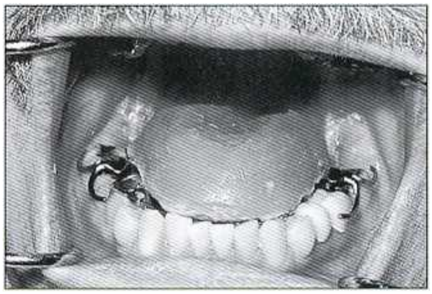


Fig 14-12 Silicone (MDX-4-4210) tongue prosthesis for both speech and swallowing. Notice the anterior and posterior elevations and the posterior midline troughlike groove.

formed in the presence of a speech pathologist when possible. After satisfactory production of these sounds, the tongue prosthesis for speech is processed in clear heat-cured acrylic resin, highly polished, then tried in the patient’s mouth (Fig 14-9).

The prosthetic tongue for swallowing is waxed in the form of a sloping troughlike base in the posterior aspect to help guide the food bolus into the oropharynx. It is then processed in denture- base acrylic resin (Fig 14-10). Both types of tongue prosthesis may be fabricated as interchangeable speech and swallowing prostheses attached via the retentive button on the base portion of the prosthesis (Figs 14-11 and 14-12).

In some instances, the mandibular tongue prosthesis can be constructed to include both features of swallowing and speech in a highly motivated patient. The framework with the processed acrylic-resin base that contains the oral “mushroom projection” (Fig 14-8a) is used for this purpose. A heavy mix of Coe-Comfort (GC America, Chicago, IT) tissue-conditioning material is added to the base and the patient is asked to move the mandible while pronouncing f, //, /?, *JJ* as the material sets. Add or remove material during this procedure until the desired sounds are attained (Fig 14-1 la). A troughlike groove is created in the posterior middle aspect of the traced tongue, and with the aid of a speech pathologist, the patient is tested for speech and swallowing small sips of water. Minor modifications can again be made by adding or removing small quantities of the tissue-conditioning material to specific areas designated by the speech pathologist until final and satisfactory tracing is done. The Coe-Comfort tracing is then removed (Fig 14-1 lb) and duplicated in MDX 4-4210 (Dow Corning, Midland, MI) silicone with appropriate intrinsic coloration and attached mechanically on the mushroomlike projection of the acrylic-resin base (Fig 14-12).

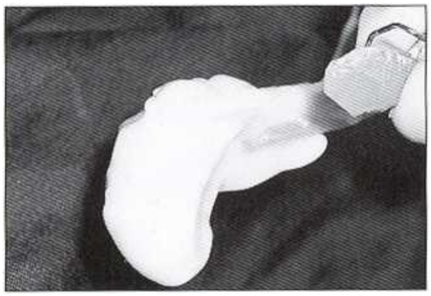


Fig 14-13a Mandibular lingual augmentation tracing in tissue-conditioning material is added to the mandibular temporary RPD.

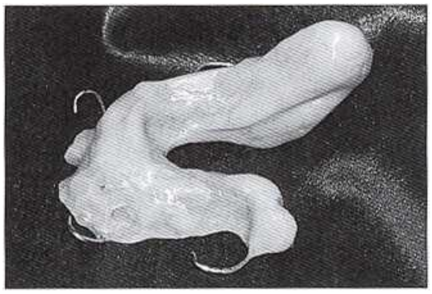


Fig 14-13b Completed mandibular lingual augmentation prosthesis.

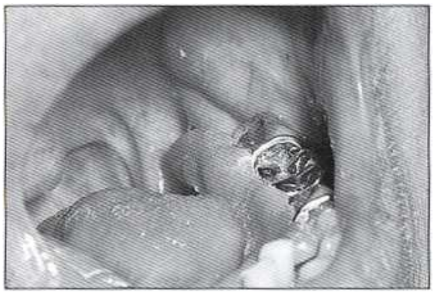
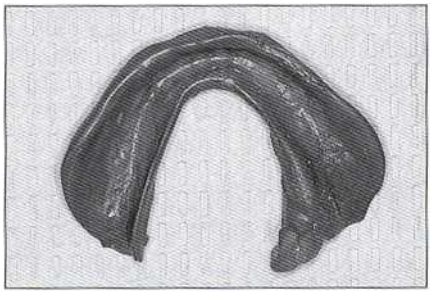
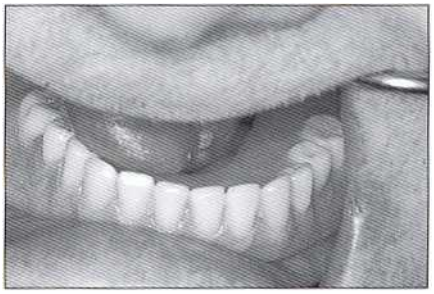


Fig 14-13c Mandibular lingual augmentation prosthesis in mouth.

Fig 14-14a *(left)* Mandibular neutral zone impression to generate the lingual augmentation prosthesis.

Fig 14-14b *(right)* Finished complete denture with the lingual flange augmented toward the tongue defect.





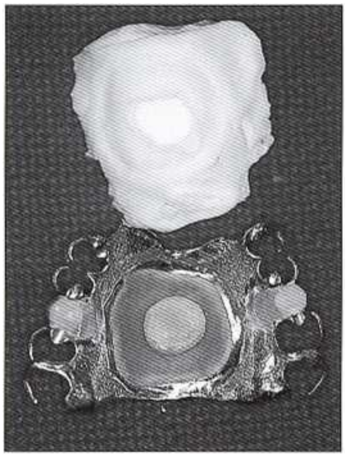
Prosthetic Treatment of Partial Glossectomy

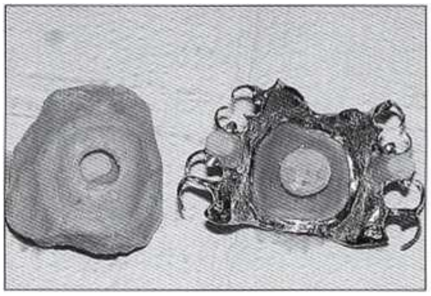
It has been demonstrated that removal of less than 50% of the tongue may result in only minor functional impairment and, consequently, prosthodontic intervention is not required (Aramany ct al, 1982). However, in cases where a patient has had a partial glossectomy and a partial mandibulectomy, there is a greater need for a glossectomy prosthesis.

Prosthodontic treatment for partial glossectomy is necessary when the patient experiences difficulty in speaking and/or managing a food bolus. When indicated, either the palatal augmentation prosthesis or a mandibular augmentation prosthesis may be fabricated. The function of the augmentation prosthesis is to fill the volume deficiency between the remaining tongue and the mandible and the-palate. The choice between a mandibular or a palatal augmentation prosthesis depends upon the availability of abutment teeth, the extent and site of the tongue deficiency', and patient acceptance.

Mandibular Augmentation Procedure

After constructing a conventional or interim mandibular removable complete or partial denture, a thick mix of Coe-Comfort tissue-conditioning material is added to the lingual flange in the area of the tongue deficiency. The prosthesis with the Coe-Comfort is inserted into the patient’s mouth, and the patient is instructed to swallow, open and close, and pronounce certain phonemes depending on the site of the resection (Fig 14-13a). Anterior resection situations require the use of consonant sounds such as *t* and *d,* while posterior defects require glottal stop execution such as *k* and ^sounds. After the tissue-conditioning material has set, a plaster matrix is made of the tissue-conditioner impression and the soft liner material is eliminated. The augmented part of the prosthesis is processed with autopolvmer- ized acrylic resin, and the prosthesis is finished, polished, and delivered to the patient with instructions for care and follow-up (Figs 14-13b and 14-13c). For an edentulous patient, the mandibular final impression is made utilizing the neutral zone technique and the denture is processed accordingly (Fig 14-14).





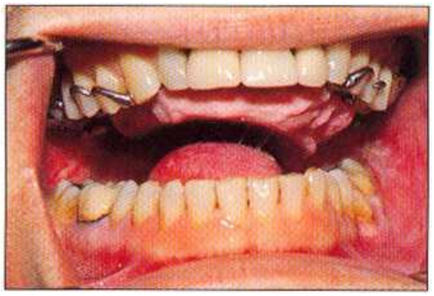
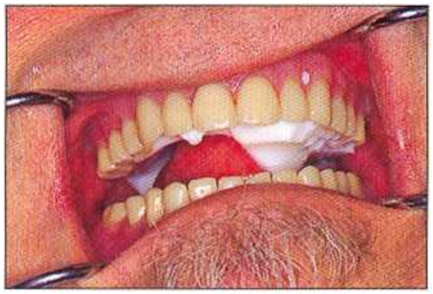


Fig 14-15a *(left)* Tissue-conditioning palatal augmentation prosthesis after tracing and immediately before duplicating into MDX-4-4210 silicone.

Fig 14-15b *(center)* Final and disassembled palatal augmentation prosthesis.

Fig 14-15c *(right)* Palatal augmentation prosthesis in the patient's mouth.



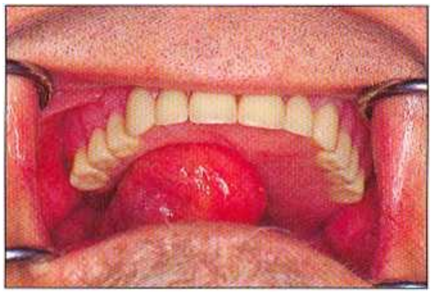


Fig 14-16a *(left)* Tracing of palatal augmentation in maxillary complete denture for a patient with partial glossectomy.

Fig 14-16b *(right)* Finished palatal augmentation added to complete denture for a partial glossectomy patient.

Palatal Augmentation Prosthesis

In dentate or partially dentate patients, a maxillary framework is designed following conventional prosthodontic techniques with an added midpalatal meshwork to retain the augmentation portion of the prosthesis. Functional molding of the augmentation portion of the prosthesis is done in a similar manner to the partially edentulous mandibular total glossectomy prosthesis however, anterior tongue position consonants are emphasized (Fig 14-15). In the edentulous patient, conventional maxillary and mandibular complete dentures are fabricated and used for a brief time (usually 2 weeks) before the maxillary denture is augmented to compensate for the tongue deficiency. A thick mix of tissue-conditioning material is added to the palatal portion of the maxillary denture. While the material is still moldable, the patient is instructed to swallow and to pronounce certain phonemes, depending upon the location of the deficiency (Fig 14-16a). Additions and subtractions can be made until the appropriate size and shape is decided upon. A plaster matrix is fabricated and the tissue-conditioning material is replaced with autopolymcrized acrylic resin. The denture is returned to the mouth and tested again for speech and swallowing (Fig 14- 16b). Further modifications can be made as reline/rebase procedures. If the palatal augmentation is large, consideration should be given to making it hollow to reduce weight.

Summary

Glossectomy prosthesis fabrication is an extremely challenging facet of maxillofacial prosthodontics. The expectations of the patient and the uninitiated speech therapist or pathologist are rarely met, and the frustration level of the prosthodontist can be very high indeed. Realistic expectations only come with experience, but with experience, the fabrication of glossectomy pros- theses can be very gratifying;

References

Aramany M, Downs J, Beery Q, ct al. Prosthodontic rehabilitation for glossectomy patients. J Prosthet Dent 1982;48:78.

Blonsky B, Logemann J, Boshes B, Fisher H. Comparison of speech and swallowing function in patients with tremor disorders and in normal geriatric patients: A cinefluorographic study. J Gerontol 1975;30:299.

Cantor R, Curtis T, Shipp T, et al. Maxillary prosthesis for mandibular surgical defects. J Prosthet Dent 1969;22:253.

Luciello F, Vergo T, Schaaf N, et al. Prosthodontic and speech rehabilitation after partial and complete glossectomy.) Prosthet Dent 1980-43:204.

McConncl F, Cerenko D, Mendelsohn M. Manofluoro- graphic analysis of swallowing. Otolaryngol Clin North Am 1988;21:625.

Mitrani M, Krespi Y. Functional restoration after subtotal glossectomy and laryngectomy. J Otolaryngol Head Neck Surg 1988;98:3.

Moore D. Glossectomy rehabilitation by mandibular tongue prosthesis. J Prosthet Dent 1972;28:429.

Myers H, Sun J. Cancer of the Head and Neck, ed 3. Orlando, l'L: Saunders, 1996: Chapter 36.

Selley W, Ellis R, Flack F, Bayliss C, Pearce V. The synchronization of respiration and swallow sounds with videofluoroscopy during swallowing. Dysphagia 1994; 9:162.

Treatment of Upper Airway Sleep Disorder Patients with Dental Devices

o John R. Ivanhoe, DDS

Upper airway sleep disorders (UASD) are becoming commonly recognized by the medical and dental communities, and patients are now being referred to dentists for treatment of these conditions using removable oral devices. Snoring is the mild form of these disorders, obstructive sleep apnea (OSA) is the severe form, and upper airway resistance syndrome (UARS) falls somewhere between the two. It has been estimated that snoring affects 25% of males (Waldhorn, 1985), OSA affects 2% to 4% of the American population (Young et al, 1993), and UARS again is seen in frequency somewhere between the two. Sleep disorders of the upper airway are generally the result of a condition or disease that causes partial or complete obstruction of the airway when the patient assumes a supine position and goes to sleep.

Anatomy

In the normal anatomy, the upper airway is a soft tissue tube, maintained by muscle activity extending from the oral and nasal cavities to the bronchial tubes (Fig 15-1). The activity and timing of the tensor veli, levator veli palatini, genioglossus, and geniohyoid muscles maintain the position of the soft palate, uvula, tongue, and hyoid bone in a position away from the posterior wall of the pharynx. It should be understood that airway patency is maintained by muscle activity, not bony structures.

The airway of snoring patients (Fig 15-2), though patent, is partially obstructed. This obstruction is very often caused by the tongue and/or hyoid bone and overlying soft tissues dropping back toward the posterior wall of the pharynx when the patient assumes the supine position and goes to sleep. In attempting to get sufficient oxygen to the lungs, there is an increase in velocity of air passing through the reduced airway space. This increase in velocity' may cause flabby tissue, often the soft palate and/or uvula, to vibrate. This vibration is the sound of snoring.

OSA patients (Fig 15-3) have an almost completely or completely obstructed upper airway. These patients may suffer from hundreds of apneic events per night, which by definition are blockages of the airway lasting more than 10 seconds (American Sleep Disorder Association, 1997) resulting in multiple arousals. These arousals cause loss of both quantity and quality of sleep, often resulting in daytime sleepiness, loss of productivity, increased auto accidents, loss of cognition, and other symptoms.

This obstruction may be caused by many conditions, including the tongue or hyoid bone and covering tissues dropping back toward or against the posterior wall of the pharynx; inflam-

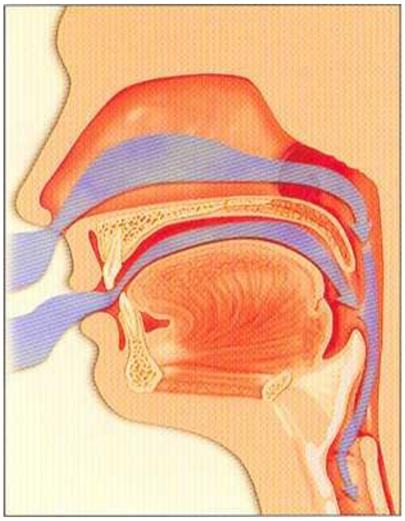


Fig 15-1 Anatomy of a normal nonsnoring patient. Note that adequate upper airway space between the uvula, tongue, and posterior wall of the pharynx allows the free flow of air during breathing.

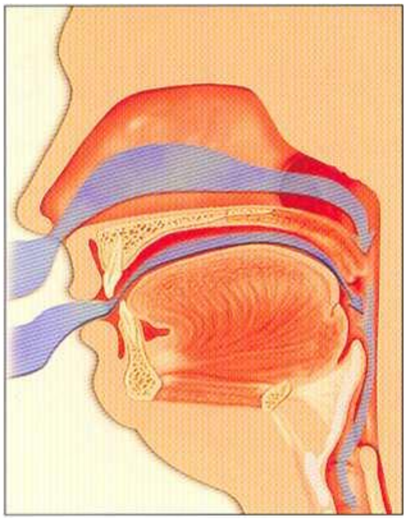


Fig 15-2 Anatomy of a snoring patient. Note the compromised but not fully obstructed upper airway space. Because this airway is compromised, the patient must increase the velocity of the air through the upper airway to obtain adequate oxygen to the lungs. This increase in airflow velocity results in vibration to soft tissue in the upper airway, in this case the uvula.

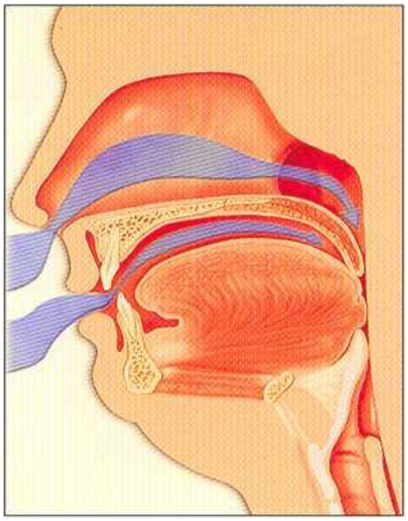


Fig 15-3 Anatomy of an obstructive sleep apnea patient. Note the completely obstructed upper airway caused, in this example, by the tongue dropping against the posterior wall of the pharynx. Obstruction can be caused by any condition resulting in tissues impinging on the airway.

mation of any soft tissue surrounding the airway, including the tonsils, adenoids, or epiglottis; tumors; obesity; and structural compromise.

Responsibilities and Limitations of the Dental Community

The dental community is responsible for the recognition of potential UASD patients, referral to a physician for diagnosis and treatment, and supporting the physician when requested. UASDs arc potentially life-threatening medical problems, and therefore all snoring or UASD patients must be referred to a physician with expertise in sleep disorders, if available, prior to initiation of any oral device to treat these disorders. Presently, a polysomnogram (sleep study) performed by a sleep lab is required to diagnose a UASD and determine its severity (Brown, 1994).

Every dentist should have a specific sleep-disordered breathing examination protocol (Table 15-1) to identify potential UASD patients. UASD patients exhibit multiple common signs and symptoms (Table 15-2). Obesity is a common symptom of OSA. As weight increases, fat is deposited in the tongue, soft palate, and surrounding pharynx areas resulting in a decreased airway (Horner ct al, 1989). Asking patients if they are tired and sleepy during the day or if they feel refreshed upon awakening will provide at least a subjective evaluation of the quality' and quantity of sleep the patient is receiving. It must be remembered that subjective symptoms while helpful are not diagnostic either before or following treatment with an oral device. Patients who report awakening from sleep gasping for air or who have been told they stop breathing while sleeping should be referred to a physician for evaluation, diagnosis, and treatment immediately.

Patients often snore only while sleeping on their backs, so assuming other sleep positions may solve the problem. Devices are available to aid in preventing a patient from sleeping on the back, and at times something as simple as pinning a rolled pair of socks to the back of pajamas may

Table 15-1 Sleep Disordered Breathing Examination Protocol

Evaluation	Indication
Weight compared with "average" and neck size	Weight loss may eliminate problem; obesity is such a common symptom of OSA that male patients with 17-inch or greater and females with 16-inch or greater neck circumference should be suspected of having OSA (Davies and Stradling, 1990)
Nasal congestion	A history of nasal congestion or of surgery to correct a breathing problem may also be a contraindication for certain dental devices that rely on a patent nasal passage
Blood pressure history	All hypertensive patients must be referred to a physician prior to fabrication of any device for treating UASDs
Alcohol and sedative consumption	Any other factors that may compromise the airway must also be considered when treating these patients, ie, alcohol and sedatives that can result in muscle relaxation allowing the tongue to drop posteriorly, resulting in a blockage, should be eliminated close to bedtime
Patient's assessment of "freshness" during the day	Indicates subjective feelings of adequate rest
Sleep position	Altering sleep position may eliminate the problem
Awakening from sleep	Indicates a potentially more serious problem
Arrested breathing during sleep	Indicates a potentially more serious problem
Frequency and loudness of snoring	A potential indication of severity
History of sleep studies or surgery	Some patients have already been diagnosed and treated
Tongue size	May eliminate certain or all devices
Periodontal and soft tissue exam	Baseline needed
Teeth sensitive to percussion	Baseline needed
TMJ evaluation	Baseline needed
Arch size	An aid in device selection
Epworth Sleepiness Scale	Self-administered survey (Johns, 1991)
Maximum protrusive movement	Necessary for device fabrication
Central incisor clearance at maximum opening	Important for patients who receive a one-piece device
Active dental care completed	All active care should be completed prior to device fabrication

Table 15-2 Common Signs and Symptoms of an Average Upper Airway Sleep Disorder Patient

Middle-age to elderly male
Hypertensive Overweight Has large neck
Consumes alcohol late in the day
Has been told he stops breathing during sleep
Does not get adequate amount or quality of sleep
Is tired and dozes during the day
Is accident prone
May awaken from sleep gasping for air Suffers from reflux
Often is retrognathic

work. Other devices are available, including wristwatch-like devices that detect the sound of snoring and vibrate to awaken the patient. This may reduce the snoring and help the bed partner but would not provide the patient with good- quality sleep.

At times patients will present to the dentist already having been identified with UASD and are actively being or have been treated. It is important to encourage these patients to continue with their treatment. If the patient is seeking a different treatment from the one prescribed by the physician, it is important that the dentist work through the physician for further treatment. The dentist must not assume the role of primary care provider for any UASD patient.

A simple self-administered survey, the Epworth Sleepiness Scale (ESS), may also be beneficial in identifying potential UASD patients (Johns, 1991). The ESS places patients in eight situations and asks the patients to give themselves points based on how likely they would be to doze in those situations. It must be remembered that the survey is a subjective patient evaluation, not a diagnostic instrument, and so subject to bias and falsification.

Tongue size and the amount of space between the soft palate and tongue are objective evaluations that may help identify a compromised upper airway or be useful in determining the type of device most suitable for a patient. An excessively large tongue may eliminate any device whose design impinges on the tongue space. All oral devices presently used to treat UASDs potentially place significant forces on the dentition, peri odontium, and/or temporomandibular joint (TMJ). Therefore, a baseline evaluation of these structures is required to provide historical data if problems develop later. A complete periodontal and TMJ evaluation is necessary, as is the determination of any existing tooth sensitivity.

Because hypertension is such a common finding in UASD patients, the blood pressure of all patients must be checked. Occasionally, a patient will request an oral device to treat only the snoring. It is tempting as a clinician to do so, but patients should not be treated without a referral from a physician, especially patients with hypertension.

All dental devices are obviously intraoral and therefore require a certain amount of space and movement of the mandible or tongue. Knowledge of the maximum protrusive movement of the mandible will be necessary when using many oral devices and the amount of vertical clearance is important for others, as will be described later.

Other important information to have available is w hether the patient is presently undergoing or will soon undergo active dental care. An intraoral device may be totally unusable to a patient if a fixed partial denture or other restorative procedure is completed following insertion of the device. If possible, fabrication of dental devices should be delayed until significant active dental care has been completed. However, it is possible to reline some of the devices, as will be described later, in situations in which unanticipated dental care renders the device unusable.

Treatment Options

Once diagnosed with a UASD,the physician has five basic treatment options: behavioral modification, surgery, continuous positive air pressure (CPAP), oral devices, and medication. Medications have proven to be of minimal benefit to patients and are not often used.

Behavior Modification

Behavioral modifications, ie, weight loss, change of sleep position, and reducing alcohol or sedative usage, have not been shown to have good long-term success; however, patients are sometimes successfully treated using these simple procedures and so they should not be overlooked.

Surgery

Surgery is often in the form of uvulopalatopharyngoplasty (UPPP), laser-assisted UPPP (LAUP), tonsillectomy, adenoidectomy, tracheostomy, mandibular advancement, or hyoid bone lift. UPPP is successful in approximately 55% of the OSA patients (Shepard and

Olsen, 1990; Rodenstein, 1992; Shcr et al, 1996), and LAUP is now indicated primarily in snoring patients. Tonsil and adenoid surgery is often of benefit in children. Because of esthetic and social compromises, tracheostomy is reserved for life-threatening situations. Mandibular advancement and hyoid lift procedures have been shown to have good success (Riley et al, 1986, 1989).

CPAP

CPAP is the gold standard for treating OSA patients but may be excessive treatment for many snoring patients. CPAP is a treatment modality that utilizes a pump forcing presurgical room air through a mask through the patient’s nasal cavity and upper airway. Although it is the most successful treatment modality for UASDs, it suffers from poor patient compliance because of the lack of portability, noise of the motor in the bedroom, and discomfort of wearing a mask while trying to sleep (Hoffstein et al, 1992).

Oral Devices

Oral devices are of two basic configurations, the tongue retaining device (TRD) and the mandibular advancement device (MAD). Oral devices generally work by directly or indirectly preventing the tongue from approaching the posterior wall of the pharynx and hence compromising the airway space. The TRDs work through the use of a hollow bulb and sufficient vacuum to hold the tongue forward. The MADs work indirectly by holding the mandible and hence the tongue forward. These devices also aid in preventing the hyoid bone from dropping posteriorly and its overlying tissues from impinging on the upper airway.

Both oral devices and UPPP have similar success rates when treating OSA, and oral devices are successful in approximately 50% of surgical (UPPP) failure patients (Millman et al, 1998). Patient compliance with oral devices is better than with CPAP. Oral devices are extremely successful in treating snoring-only patients.

The TRD is a single-position device that does not depend on protrusion of the mandible. MADs arc cither adjustable or single-position devices. Single-position MADs depend upon the clinician properly determining the protrusive position that will eliminate the snoring and/or OSA but at the same time will not cause TMJ discomfort. The TRD is laboratory fabricated; MADs may be stock devices or laboratory fabricated. There are approximately 40 oral devices for the treatment of sleep disorders currently available.

MADs are generally hard-plastic impression tray shells filled with a thermoplastic retentive material. One-piece devices usually fit over both the maxillary and mandibular arches simultaneously and may or may not allow movement between them. Two-piece devices consist of separate maxillary and mandibular trays that fit over their respective teeth individually and allow movement between the arches. Most MADs depend upon excellent retention to the remaining teeth and use a thermoplastic fill material to provide the necessary retention and to allow custom fitting to the teeth.

Although many commercial devices exist, only a single example of several will be used to illustrate the techniques of fabricating these devices. Using them as examples is in no way an endorsement of the particular products.

Common Techniques and Procedures

Many of the devices have techniques and procedures in common, including obtaining a specific desired protrusion of the mandible and the use of thermoplastic fill material. Thermoplastic fill material is used to fit the devices to the remaining teeth for retention at the insertion and to readapt the device to the teeth if retention is lost.

Obtaining the Desired Protrusive Position of the Mandible

Many devices require that casts and intcrocclusal records be sent to a laboratory for device fabrication. The interocclusal records will often be made with the patient protruded 70% to 75% of their maximum protrusive movement. In the example

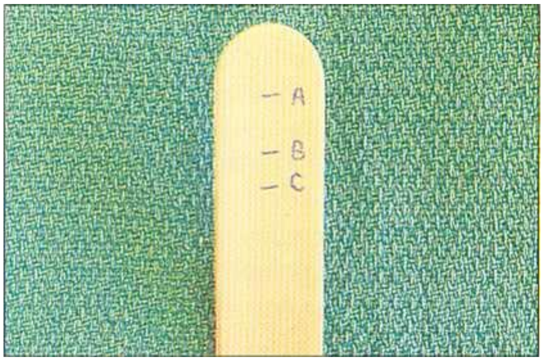


Fig l 5-4 This tongue blade has been used to determine the retruded position (A), maximum protrusive movement of the mandible (C), and desired protrusive distance to be used for fabrication of the oral device (B). Note that the distance between the retruded position mark (A) and the desired protrusive distance (B) is about two thirds the distance between (A) and the maximum protrusive movement (C).

below, 70% is the manufacturer’s recommendation for the particular device being fabricated.

A tongue blade is placed between the maxillary and mandibular incisors with the patient in the normal retarded occlusal position (Rivcra- Moralcs et al, 1996). A small mark is made on both the top and bottom of the tongue blade in the midline and against the maxillary and mandibular incisors. Holding the tongue blade so that the mark on the maxillary side of the tongue blade is in its initial position, the patient is asked to thrust the mandible as far forward as possible in a protrusive movement with minimal lateral deviation. A second mark is made indicating the patient's maximum protrusive position. Seventy percent of the difference between the two marks is determined by measuring the distance between the two marks and multiplying the distance by 0.7. This position, 70% of the distance between the maximum intercuspation and maximum protrusive position, is indicated on the bottom of the tongue blade by measuring anteriorly from the most posterior initial mark toward the second mark. Make a third mark at this position. This third mark will obviously be approximately two thirds the distance from the first mark to the second (Fig 15-4). When making the inter- occlusal record, the tongue blade is positioned so that the mark on the maxillary arch is maintained in its initial position, and the patient is instructed to move the mandible forward until the incisors touch the mark indicating 70% position. An interocclusal record is made at this point. The George gauge (Great Lakes Orthodontics, Tona- vvanda, NY) is a handy device that simplifies the visualization of both the retruded and maximum protrusive positions and aids in determining and recording the percentage of the protrusion to be used for initial fabrication of an oral device.

The tongue blade is also used to determine the maximum vertical opening of the mandible. The patient is asked to open to maximum height, and one end of the tongue blade is placed on the mandibular central incisors in the midline. An edge of the tongue blade is placed against the midline of the maxillary central incisors and the level of the incisal edge of the incisors is indicated by a mark. The distance from the end of the tongue blade to this mark indicates the maximum vertical opening in the incisor area. This distance is very important for those patients who receive a one-piece oral device since these devices often require 30 to 40 mm of vertical opening to allow insertion of the device.

Fabricating Different Oral Device Types

Single-Position Stock Devices

These devices are generally fabricated from two rigid-plastic shells in the shape of impression trays joined into a single unit. The trays fit over both the maxillary and mandibular teeth simultaneously and receive retention from a thermoplastic fill material. They are generally inexpensive, are used to diagnose the success potential of oral devices, and are often temporary.

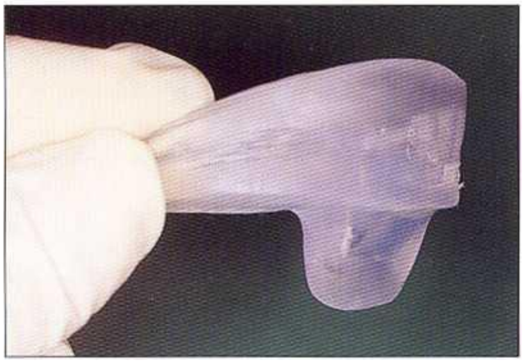


Fig 15-5 Example of a single-piece single-position stock device (TheraSnore). Note the lingual projection or flange extending below the plane of occlusion on the mandibular side of the device. This flange will prevent the mandibular arch from moving posterior during sleep.

The particular device (TheraSnore, Distar, Albuquerque, NM) (Fig 15-5) is somewhat unusual in that it is retentive only on the maxillary arch. The mandibular side of the device has a lingual projection or flange of the hard-resin tray material extending linguallv below the plane of occlusion axtd behind the mandibular anterior teeth. Retention is not required on the mandibular arch because the lingual surfaces of the mandibular anterior teeth are in direct contact with this lingual projection, which prevents the mandible from dropping posteriorly. Because there is no retention of the mandibular arch, the mandible may drop open several millimeters during sleep. For most patients, this opening is insignificant; however, on some patients the mandible may drop a sufficient distance that the lingual projection cannot prevent the mandible from falling posteriorly, causing the patient to snore and/or become obstructed.

The patient is instructed to protrude the mandible approximately 70% of maximum protrusive movement and then close into the tray and warmed thermoplastic fill material. Before actually attempting to fit the device, the patient should practice this maneuver several times, remembering to protrude in a forward direction with minimal lateral deviation. This particular device is placed in a hot-water bath set to 15()°T until the thermoplastic material loses all opaqueness, indicating that the material is thoroughly softened.

The tray is centered and completely seated on the maxillary arch until the occlusal and incisal edges of the teeth seat firmly against the hard-plastic tray material. While the thermoplastic material is still very soft, the patient is instructed to project the mandible to the predetermined distance and close the mandibular teeth into thermoplastic material, once again closing until the teeth touch the hard-plastic tray.

The thermoplastic material is adapted to the teeth, removed, chilled, and the maxillary trimmed as described below. Retention is absolutely necessary on the maxillary arch, but if lost, it may be re-established by adding small pieces of the trimmed material. As stated above, the device is designed not to be retentive on the mandibular teeth but to provide vertical stops on as many teeth as possible and yet allow several millimeters of freedom of movement to the mandible in protrusive and lateral movements. Therefore, any trimming on the mandibular side of the device is completed with these objectives in mind. Centric-occlusion vertical occlusal stops of the anterior and posterior teeth are identified using articulating ribbon or tape. The surface of the material is trimmed flat with an acrylic bur so that the identified vertical stops remain but no material remains above these contact points. Next, any prematurities preventing the mandible from freely moving in a protrusive direction are identified in both the anterior and posterior areas and removed with the acrylic bur. Finally, prematurities that prevent at least 2 mm of lateral movement of the mandible are removed. The initial prematurities arc generally lingual to the canines. Because of the curvature of the arch, a significant amount of grinding may be necessary in these areas. Slightly roughened remaining sur-

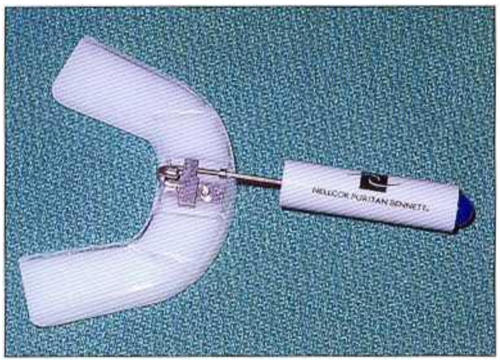


Fig 15-6 Example of a two-piece adjustable-stock device (QuietKnight). This is the maxillary tray of the two-piece device. Note the adjustable screw, screwdriver, and wire with hook extending toward the lingual of this device.

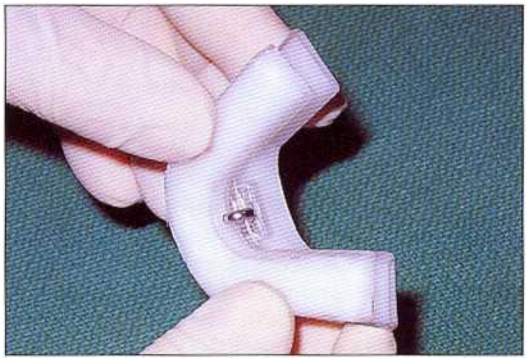


Fig 15-7 Lingual view of both the maxillary and mandibular trays of the two-piece adjustable stock device as viewed from the lingual. Note the wire hook of the maxillary tray and the plastic lingual ledge of the mandibular device. Adjusting the screw mechanism on the maxillary tray moves the wire hook in either an anterior or posterior direction. By pulling on or releasing pressure from the lingual plastic ledge, the mandible is either pulled in an anterior direction and indirectly moves the tongue away from the posterior wall of the pharynx or the mandible is allowed to drop more posteriorly, reducing stress on the TMJ.

faces can be rounded using an alcohol torch, but care must be taken not to burn or overheat the material, since distortion can occur.

Single-Position Laboratory- Fabricated MADs

There are several single-position laboratory-fabricated devices available; however, their fabrication is often a combination of techniques described for the other devices. Therefore, they should be fabricated using these techniques and the manufacturer’s instructions.

Adjustable Stock MADs

These devices are generally shaped like plastic impression trays. The trays arc filled with thermoplastic material for fitting to the patient with some mechanism for adjusting the mandible in a protrusive and retrusive direction. QuietKnight (Ncllcor Puritan Bennett, Pleasanton, CA) is such a device with a screw mechanism for positioning the mandible.

QuietKnight consists of a maxillary hard-plastic tray with a screw mechanism attached to a wire hook (Fig 15-6) and a mandibular hard- plastic tray with a plastic ledge running between the canines on the lingual. The hook on the maxillary arch engages the plastic ledge on the mandibular arch (Fig 15-7). For every full turn of the screw, the wire hook moves 0.25 mm in either a protruded or retruded direction, thereby moving the mandible in the same protrusive or retrusive direction. As with any stock device, a disadvantage is that there are only a limited selection of tray sizes and shapes available. For the maxillary arch, the choices arc medium and large, each available with a standard or long hook. The difference in hook length is necessary to accommodate patients with retruded, normal, or protruded mandibles. The mandible has a single-size tray, but either a regular or extended shelf can be selected, depending on the relationship of the maxillary teeth to.the mandibular teeth. To determine which selections are appropriate, the company provides an EZ-Bite sizing gauge, very similar to the George gauge. The manufacturer also recommends several treatment sequences utilizing different maxillary and mandibular tray combinations depending on the arch sizes and relationships.

Once selected, the trays arc adapted to the individual arches and properly contoured as described below. This device has unusual instructions in that the manufacturer recommends the device be placed in boiling water to expedite the softening of the thermoplastic material. When the thermoplastic material has cleared, the temperature of the water has dropped to an acceptable level that the device can be inserted without burning the tissues. It may be tempting to place the device in the water and heat both in the microwave simultaneously; however, this must not be done because the thermoplastic material will remain clear when the temperature is still at a level that will severely burn the patient. This device is an exception also in that a Styrofoam block that covers the metal hook is provided. The Styrofoam block aids in preventing burns to the patient's lips and tongue following heating of the device in boiling water. The patient is instructed on titration and home care as described below.

Adjustable Laboratory-Fabricated MADs

All laboratory-fabricated devices require maxillary and mandibular casts and many require an interocclusal record. Some of the devices arc two pieces that can be inserted singly onto the maxillary arches, and some are single units in which the entire device is inserted onto both arches simultaneously. These devices often require 30 to 40 mm of vertical opening to fit over both arches at the same time.

The Adjustable PM Positioner (Davis Dental laboratory, Grand Rapids, MI) is a single-unit device that is somewhat unusual in that it has an adjustment screw located on the buccal of the arches bilaterally (Fig 15-8). Many adjustable devices have a single screw located in the anterior or palatal area. A potential disadvantage of this device is that patients must be very careful when adjusting the screws that an equal adjustment is made bilaterally. All fixed restorations and periodontally involved teeth are indicated on the work authorization so the lab can provide slight relief in these areas. This relief is required because the devices are very retentive and may loosen a restoration or traumatize periodontally compromised teeth.

Because this is a laboratory-fabricated device, casts and interocclusal records arc necessary. The interocclusal records are made at approximately 50% of maximum protrusion and with at least 5 mm of clearance between the anterior teeth. The desired protrusive position is determined as described above and the patient is allowed to practice assuming the position. The clinician should ensure that the patient makes a straight protrusive movement with no lateral deviation. The midlines of the anterior teeth can be used to determine the proper protrusive movement direction. To maintain the 5 mm of clearance, a sheet of baseplate wax can be cut in half, one half heated in warm water, and folded over on itself several times, forming a bite block of approximately 8 mm in thickness. The patient is instructed to protrude the desired distance and close into the anterior baseplate bite block being sure to maintain the required 5 mm. Once completed, the bite block is chilled to rigidity. Interocclusal recording material (ie, polyvinyl - siloxane) is placed between the posterior teeth, and the patient is instructed to close into the bite block, ensuring the desired protrusive position with the required vertical height (Fig 15-9). The casts, records, and work authorizations are submitted to the laboratory (Fig 15-10).

The laboratory will return a completed device with instructions and a wrench to turn the screws. The device is one piece with orthodontic wire attached to the screw devices and joining the maxillary and mandibular trays. These wires are not strong enough to withstand tremendous torquing forces and will potentially bend under heavy loads; therefore, patients must be instructed to carefully remove the devices one arch at a time. Using.the fingers, the mandible is opened and the device is pulled down and off the maxillary teeth. It is then lifted off the mandibular teeth in a separate movement. Because the wires are not rigidly attached, some movement is

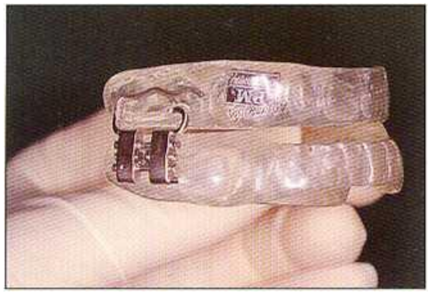


Fig 15-8 Adjustable PM Positioner. Even though this is a single-piece device, some movement of the mandible is allowed through its design. A single orthodontic screw mechanism is seen from this angle, but there is a second mechanism on the opposite side. The patient must be cautioned to adjust both screws equally.

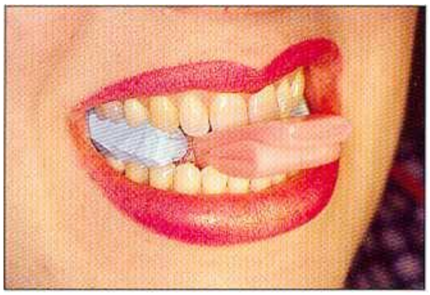


Fig 15-9 Technique for making an interocclusal recording with an anterior wax index holding the incisor teeth open 5 mm vertical and 50% forward of the retruded position.

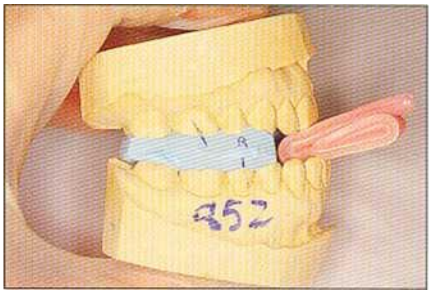


Fig 15-10 Casts prepared for shipment to the laboratory with the anterior index and interocclusal recording.

allowed between the maxillary and mandibular arches. The device can be adjusted to achieve proper coverage of the teeth and desired retention. In my experience, very few adjustments have been required with these devices.

The patient is instructed to remove the device daily and to practice proper home care. The proper titration of the device is also discussed with the patient. The device should be worn in its initial setting until the patient feels comfortable. If the patient experiences discomfort to the teeth or gingiva, the device is adjusted as described below. If successful results have not been achieved or if the patient experiences TMJ discomfort, the device must be titrated as described below. This titration procedure may take days, weeks, or months to achieve the desired results, and the patient should be so informed.

Tongue Retaining Device (TRD)

The TRD (Fig 15 11) (Professional Positioners, Racine, Wl) is an excellent device for edentulous patients or those who suffer from TMJ sensitivity. This is a one piece device made of a nonrigid vinyl material without thermoplastic material to adapt to the teeth. Retention to the teeth or residual ridges is not a requirement with this device, and therefore rigidity of the device is unnecessary.

Fabrication of this device is reasonably simple but requires that a clinician complete a training program or purchase a videotape explaining the fabrication technique. A kit containing two hollow bulb templates (Kelgaugcs), standard blue and wide yellow, must also be purchased. The templates are basically hollow bulb devices with tabs on the sides and ridges on the top of the tray of the device (Fig 15-12). The templates can be used to select the proper bulb size necessary to create a vacuum to hold the tongue, to position the bulb to achieve the desired tongue protrusion, and as a tray to hold interocclusal recording material while the patient closes into maximum intcrcuspation position.

The standard bulb template is inserted and the patient instructed to protrude the tongue into the bulb. A vacuum must be present to retain the tongue in the hollow bulb. Air can be squeezed out of the bulb to help achieve the vacuum since the device is fabricated from a flexible vinyl material. If the standard template is too narrow, then the wide template is used. Once the proper bulb size is selected and the tongue is well retained in the hollow bulb by the vacuum, the patient is asked to protrude the tongue the maximum comfortable distance possible, and the incisors are closed onto the anterior part of the template. As mentioned earlier, this part of the template has several ridges separating smooth surfaces onto

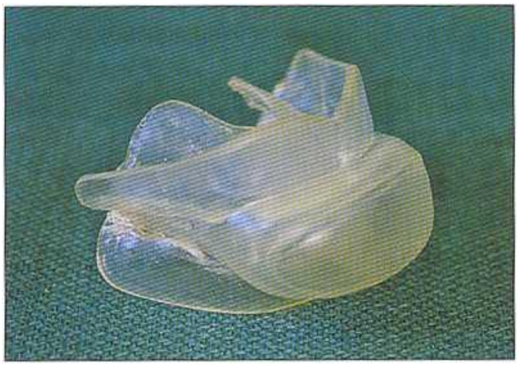


Fig 15-11 Example of the single-piece, flexible tongue retaining device (FRD).

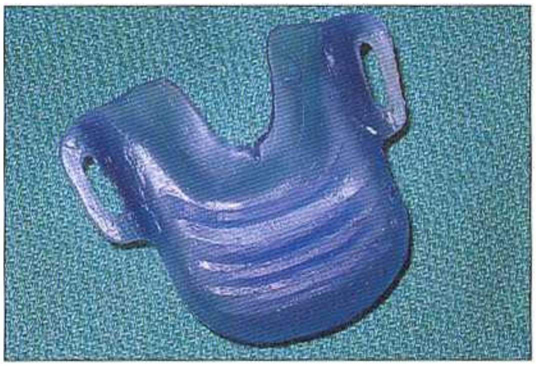


Fig 15-12 Example of the standard Kelgauge template used to determine the size of the hollow bulb and proper anterior position of the tongue for maintaining an adequate upper airway space and to fabricate interocclusal records. Note the tabs on the sides of the device that will support the interocclusal recording material.

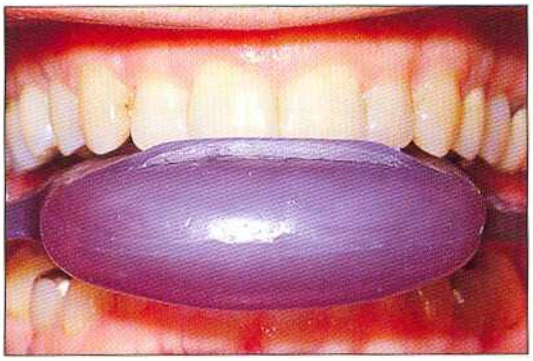


Fig 15-13 Maxillary central incisors contacting the device between the ridges. The Kelgauge template is protruded as far forward as the tongue can comfortably go and the position of the central incisors in relation to the ridges is noted. The interocclusal record is made at this position.

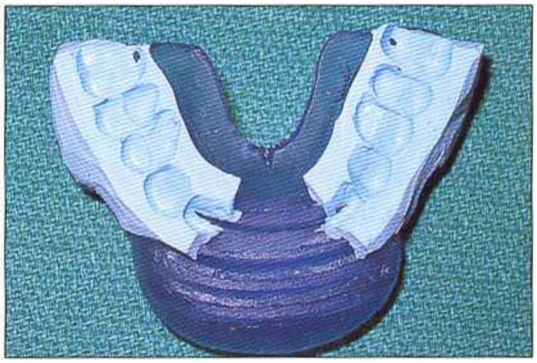


Fig 15-14 Kelgauge with interocclusal recording material supported and retained by lateral tabs.

which the maxillary incisors close (Fig 15-13). The area the incisors close onto is noted and the device removed from the mouth. Polyvinylsil- oxane, bite-recording material, is placed on the tabs on the sides of the template, and the patient is instructed to again close the maxillary incisors into the correct smooth area as determined previously. This recording places the template in the correct anterior-posterior position to properly hold the tongue away from the posterior wall of the pharynx. The Kelgauge template with recording material and diagnostic casts is sent to the laboratory that fabricates the actual TRD for the patient (Fig 15-14).

Since the effectiveness of these devices depends upon holding the tongue forward in the hollow bulb and does not depend upon retention from the remaining teeth, no thermoplastic material is used. They fit rather loosely when returned from the laboratory, and because titration is not possible, their insertion and follow-up is generally simplified. When initially inserting the device, the patient is instructed to place the device over both arches and push the tongue into the hollow bulb. The patient is then instructed to create a vacuum in the oral cavity', which will include the hollow bulb area, and over both the maxillary and mandibular teeth. The bulb is squeezed using the fingers of both hands until as much air as possi-

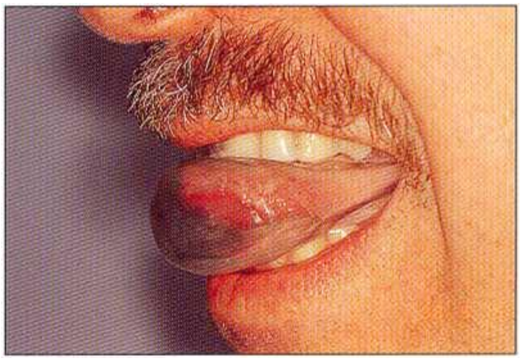


Fig 15-15 Completed TRD inserted. Note the tongue retained within the hollow bulb.

ble is removed from the bulb and a significant vacuum is created, especially around the tongue. The patient is then instructed to relax the lips and release the vacuum around the maxillary and mandibular arches. It may be necessary for the patient to use his or her fingers to slightly pull the device away from the maxillary arch, thereby allowing air to enter the area around the maxillary teeth. The same may be necessary with the mandibular arch. The vacuum must not be allowed around the teeth and gingiva because of the potential for exacerbating periodontal problems. With practice, the vacuum holding the tongue is maintained while the vacuum around the teeth and gingiva is released. For the device to be successful, the tongue must be well retained within the hollow bulb by the vacuum at this point. It should be difficult to pull the device off the tongue.

The borders of the device are evaluated for excessive pressure or overextensions, which can be relieved with an acrylic bur. Edentulous patients often require more adjustments than dentate patients because their diagnostic casts were fabricated from alginate impressions that often are overextended in the vestibular areas.

The patient is instructed to protrude the tongue into the hollow bulb and the vacuum should hold it there for several hours per night (Fig 15-15). A minimum of 6 hours of sleep with the device inserted should be the goal for the patient. Patients should be informed that initially upon wearing the TRD their tongue may become slightly numb and tingle, but these symptoms should be transient. They may also expect dryness and soreness of the throat, but using a mouthwash two to three times daily should relieve those symptoms.

The TRD should be thoroughly cleaned each morning with soap and warm water. A soft toothbrush may also be beneficial. The device should be allowed to dry and stored in a container or plastic bag. It should not be allowed to remain damp over prolonged periods because of the possibility of mold growth. The vinyl will not warp if it dries out.

MAD Insertion, Adjustment, Titration, and Follow-up

Fabricating and inserting oral devices is reasonably simple and straightforward in most patients, but titration of MADs, adjustment, and followup care are often frustrating for both the clinician and the patient since they may be quite prolonged.

Insertion and Thermoplastic Fill Material

Because so many of the devices use thermoplastic fill material, the basic technique for using the material will be discussed separately from the individual device types.. Thermoplastic material is a semirigid opaque plastic material that softens and loses its opacity in warm to hot water but becomes rigid and opaque again upon cooling. Different manufacturers apparently use different

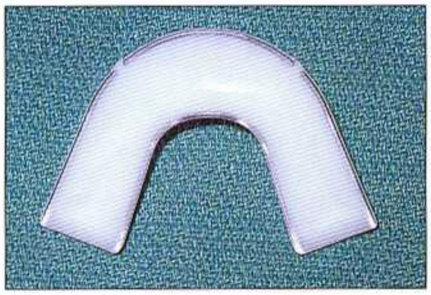
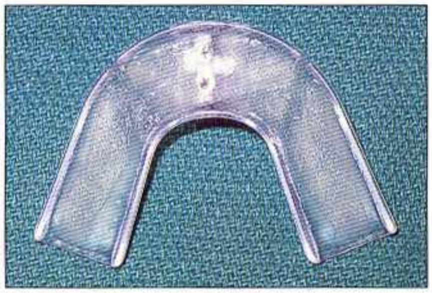



Fig 15-16a *(left)* Example of a device with the thermoplastic material cool and opaque.

Fig 15-16b (*right*) The same device illustrating that the thermoplastic material has been adequately heated and has lost all evidence of the original opacity. No attempt should be made to seat a device until all thermoplastic material is completely warmed and clear.

thermoplastic materials since a range of temperatures, from 150° to 212°F, is recommended for adequate heating of the material in different devices.

A large cup or bowl with a handle is selected to heat the water. It must be wide enough to hold a one-piece device without the device touching the sides. The cup must also be tall enough so that the water level is approximately 2 inches below the lip of the cup and yet still covering the entire device. These 2 inches are needed for those devices whose manufacturers recommend placing the device directly in boiling water. To save chair time, it is convenient to have two cups. The dental assistant can heat the water in the first cup to the desired temperature and place the device in the water to thoroughly soften the thermoplastic material. The second cup is placed in the microwave to begin heating the water. The first cup with the device in the water is delivered to the clinician and the initial attempts are made to insert the device. Occasionally the device may not be absolutely seated against the teeth or perhaps not adequately contoured around the teeth. By this time the first cup of warmed water will not be sufficiently warm to adequately reheat the thermoplastic. The dental assistant can get the second cup of warm water and begin reheating the first cup to be ready if needed.

Hot-water baths may be used to heat the water; however, some baths may not reach temperatures high enough to thoroughly soften the thermoplastic material. In addition, hot-water baths require prior preparation and may be slow. Microwaves are most often used since they are fast and no prior preparation is required. Whichever method to heat the water is selected, a thermometer must be used because knowing the actual water temperature is important to eliminate any chance of burning the patient. When the thermoplastic material has lost its opacity and the temperature of the water has dropped to an acceptable level, the device can be inserted without burning the tissues.

Using the manufacturer's recommendations for the proper water temperature, the thermoplastic material is softened and the device properly positioned over the teeth and seated so that the teeth are completely in occlusal and incisal contact with the hard-plastic tray material. It is absolutely necessary that the material be completely transparent (Figs 15-16) before removing it from the hot water and attempting to seat the tray on the teeth. If the material is even slightly opaque it is not sufficiently softened to allow complete seating on the teeth. There should be minimal resistance to tray placement if the material is properly softened. A finger is used to adapt the excess material against the buccal and lingual

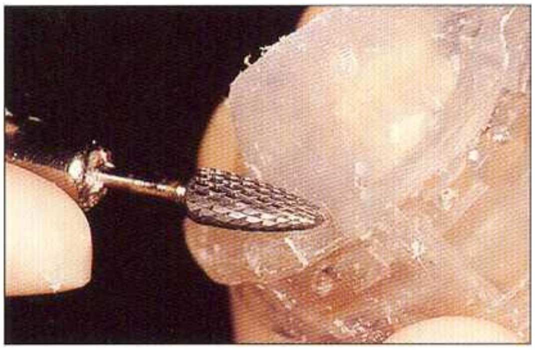


Fig 15-17 A large flame-shaped acrylic bur is used to trim most devices where necessary. Material should be removed from gingival contact and relieved in areas of undercut. Remember to place the device in ice water occasionally while trimming to minimize distortion of the material from overheating.

surfaces of any remaining teeth while the material is still soft. To prevent possible locking of the thermoplastic material in areas of undercuts, the device is lifted off the teeth, reseated several times, and ultimately removed from the mouth while the thermoplastic material is still somewhat soft. The device is immediately placed in ice water to make the thermoplastic material rigid. At this point it will usually not fit back in the mouth because some of the rigid thermoplastic material will be in areas that are undercut to the path of placement of the device.

To begin to initially fit the device to the arches, a large tapered acrylic bur is used to remove all material in contact with gingival tissues (Fig 15-17). When cutting with the acrylic bur, the material will heat, become stringy, and stick to the bur and surrounding tray. The device should be returned to the ice water often as the trimming progresses to eliminate excessive heating and warping of the material. Next, excess material in areas of undercuts, interproximal of the teeth, and under fixed restorations should be relieved. Adequate material reduction is absolutely necessary so that the device can be inserted and removed, yet care must be taken not to reduce the material too much during this trimming procedure so adequate retention is maintained. When completed, the device must not impinge on gingival tissues and should be very retentive yet not cause excessive pressure to the remaining dentition. At times, a sharp knife (ie, Bard Parker) may be necessary to remove material in small hard-to-reach areas or sharp edges. A reasonably smooth surface should result from using the acrylic bur and knife.

Once trimmed, the device is retried in the mouth. If it will not go back into place or if pressure causes any tooth discomfort, the thermoplastic material may again be softened by returning it to the hot water for approximately 15 seconds and retried in the mouth. Again it should be lifted and reseated and then removed and chilled. This is continued until the device will seat around the teeth and yet still be very retentive. If retention becomes inadequate because of excessive removal of thermoplastic material or excessive heating and readapting of the device to the teeth, it must be re-established. To regain adequate retention, some of the pieces of excess material trimmed from gingival and undercut areas earlier are returned to the tray. The tray is reheated until the thermoplastic material has again cleared and become one single mass. All procedures described above are followed until the device is properly adapted to the teeth and gingiva and is retentive yet comfortable.

In finishing the device, any grossly rough or sharp areas should be refined with the acrylic bur or sharp knife. Slightly roughened remaining surfaces can be smoothed and rounded by gently flaming those areas using an alcohol torch, but care must be taken not to burn or overheat the material since distortion can occur.

Titration

Titration of these devices is the process of slowly moving the mandible into a more protruded or retruded position until the minimum possible advancement of the mandible is achieved, snoring is eliminated or at an acceptable level, and there is

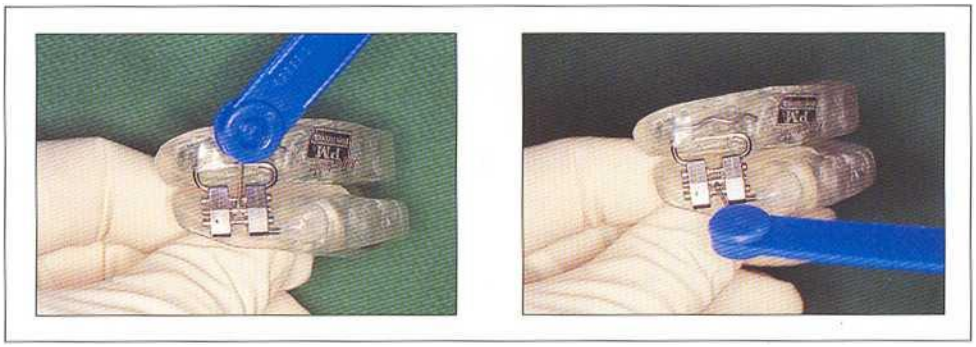


Fig 15-18a *(left)* Adjustable PM Positioner being adjusted. Note the wire key used to turn the screw is in the topmost hole.

Fig 15-18b *(right)* Note that the screw has been turned until the wire key is in the lowest position. This mandible has been advanced 0.25 mm. Returning the wire key to the uppermost position would allow the mandible to retrude the same distance.

no prolonged TiVlJ or tooth sensitivity upon awakening. Titration should be delayed for the first several nights until the patient is able to sleep comfortably with the mandible in its initial advanced position. Since there are many oral devices available with multiple methods of protruding or retruding the mandible from its initial advanced position, only one of the more common devices that utilizes a screw mechanism for adjustment will be described. Many of the other devices follow this general procedure.

If the device reduces snoring to an acceptable level or eliminates it following insertion and no TMJ or tooth discomfort is reported, titration is not necessary and the device can be worn with the mandible in its initial position. However, if the snoring level is not acceptable, then the mandible is slowly protruded 0.25 mm per night (Figs 15-18) for no longer than 2 weeks, at which time the patient is re-evaluated. This protrusion is resumed and continued until the desired snoring results are achieved, TMJ discomfort begins, or the screws reach the end of their adjustment potential. If the screws reach the end of their adjustment potential, the device must be remade beginning with the mandible in a more protruded position when the device is initially inserted. This will require that new interocclusal records be made in a more protruded position.

TMJ discomfort is generally transient but occasionally becomes a concern. If unacceptable TMJ pain is experienced, the screws are closed 0.25 mm nightly, allowing the mandible to retrude until the pain is eliminated. If the pain persists, it may be necessary to remove the device for several days and possibly prescribe 800 mg of ibuprofen daily for 2 to 3 weeks or until the symptoms are relieved. If the TMJ discomfort cannot be eliminated with wearing of the device, the patient cannot tolerate the required protrusive movement of the mandible and a TRD may be indicated since no mandibular protrusion is necessary with it. A constant vigil is also necessary with these devices since either occlusal changes, TMJ discomfort, snoring, or OSA at any point can begin to be a problem. Further titration will usually eliminate the problem.

Once the appropriate titration has been completed, the patient should be referred back to his or her physician for re-evaluation by another sleep study. In determining the success of an oral device, the patient's subjective symptoms may not be reliable. The dentist can only hope to eliminate or greatly reduce some or most of the symptoms of snoring and/or obstruction (see Table 15-2) and then return the patient to his or her physician for follow-up evaluation. It must be remembered that in a certain percentage of patients, an oral device can potentially cause or increase an obstruction problem.

Follow-up Care

Follow-up evaluation at 2 weeks, 1 month, and then at 6-month intervals is absolutely necessary to evaluate retention, gingival conditions, tooth mobility and sensitivity, and frank tooth movement. It is possible that up to 10% of patients wearing MADs will experience irreversible tooth movement that will require major oral rehabilitation and/or orthodontics to restore proper occlusion. This condition may not be apparent for several years postinsertion.

Patients will report a loss of retention or significant staining of the material in their device over a period of months. Some manufacturers sell the thermoplastic fill material as a separate item for use in relining or replacing the material in the devices as necessary. All, part, or none of the old fill material may be removed when relining a device. If all the old fill material is removed from a device, one third ounce of new fill material will generally replace the entire mass. It is warmed in hot water; rolled into a cigar-shaped mass; placed in the empty tray; and the device placed, adapted, and adjusted just as was done at the initial insertion.

Expectations and Home Care

What the Patient Should Expect

When the devices arc initially placed, patients often experience several problems, including difficulty going to sleep, chapped lips, dry throat, sore teeth, sensitive TMJs, and maloccluding posterior teeth upon awakening (Thornton and Roberts, 1996). Patients should be advised to use lip balm before retiring at night and told that the dry throat is only transient. Patients who have difficulty falling asleep may be advised to go to sleep without the device and have their bed partner awaken them to insert the device when the snoring starts. Many patients can fall back to sleep easily.

Other symptoms (ic, sore teeth, sensitive TMJ, and maloccluded posterior teeth) should disappear within a couple of hours of removing the device in the mornings. If not, the device must be adjusted. An adjustment generally is necessary because of sore teeth caused by uneven pressure in one area. At times this sensitivity' can be eliminated by resoftening the thermoplastic material and the device readapted to the teeth. At other times the sensitivity' is caused by pressure from the hard-plastic tray on individual teeth. In these situations, the pressure areas arc determined and adjustment completed with a small acrylic bur. The device is refinished with an alcohol torch as necessary.

Home Care

Most of these devices should be treated as if they were removable prosthodontic or orthodontic devices. When removed in the morning they should be thoroughly rinsed and cleaned with a small, soft toothbrush or denture brush. Some manufacturers recommend using a mild toothpaste. They can occasionally be soaked in some type of denture cleaner for stain removal. Most manufacturers recommend storing the devices dry in a closed container. The manufacturer’s instructions should be followed in the care and maintenance of these devices.

Summary

I have found two-piece adjustable devices with thermoplastic fill material to be easy to use for most patients. They do not require as much inter- occlusal space to place as one-piece devices do, the thermoplastic material allows multiple adjustments and relining as necessary, and the adjustability allows the mandible to be protruded the minimum distance necessary to achieve satisfactory results. Table 15-3 lists some of the factors that may be considered when selecting an oral device for the treatment of UASDs.

While it was not possible in this chapter to cover every important topic related to the field of sleep disorders,-such as pulse oximetry, magnetic resonance imaging, cephalometric studies, definitions, and apnea severity, this overview does offer dentists the diagnostic and treatment options of UASD patients.

Table 15-3 Considerations in Selecting a Device

Consideration	Comment/Suggestion
Ease of use for patient	Devices that require no titration are easier for patients but may not reduce or eliminate the problem
Stock or laboratory fabricated	Stock devices do not require impressions or interocclusal records but do not fit all patients; laboratory fabricated devices require two visits to fabricate and insert, but the combined time of the two visits may be shorter than the one visit to place a stock device
Materials	Choose a device that has thermoplastic fill material for adjusting the retention
Minimal repairs	Choose a durable device
Patient comfort	Some devices are less bulky than others and some impinge on the tongue space less than others
Effectiveness	Many devices are not adjustable and therefore may not be effective
Potential TMJ problems	May be minimized with a TRD
Potential tooth movement	Choose a device that covers all teeth and minimizes individual tooth movement

References

American Sleep Disorder Association. Obstructive sleep apnea syndrome. In: The International Classification of Sleep Disorders: Diagnostics and Coding Manual, 1997:337.

Brown LK. Sleep apnea syndromes: Overview and diagnostic approach. Mt Sinai J Med 1994;61:99.

Davies RJO, Stradling Jll. The relationship between neck circumference, radiographic pharyngeal anatomy, and the obstructive sleep apnea syndrome. Eur Respir J 1990; 3:509.

Hoffstein V, Viner S, Mateika S, et al. Treatment of obstructive sleep apnea with nasal continuous positive air way pressure. Patient compliance, perception of benefits, and side effects. Am Rev Respir Dis 1992;145:841.

Horner RL, Mohiaddin RH, Lowell DC, et al. Sites and sizes of fat deposits around the pharynx in obese patients with obstructive sleep apnea and weight matched controls. Eur Respir J 1989;2:613.

Johns MW. A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. Sleep 1991;14:540.

Millman RP, Rosenberg CL, Carlisle CC, et al. The efficacy of oral appliances in the treatment of persistent sleep apnea after uvulopalatopharyngoplasty. Chest 1998;113:992.

Riley RW, Powell NB, Guilleminault C. Inferior mandibular osteotomy and hyoid myotomy suspension for obstructive sleep apnea: A review of 55 patients. J Oral Maxillofac Surg 1989;47:159.

Riley R, Powell N, Guilleminault C, ct al. Maxillary, mandibular and hyoid advancement: An alternative to tracheostomy in obstructive sleep apnea syndrome. Otolaryngol Head Neck Surg 1986;94:584.

Rivera-Morales WC, Boldman BM, Jackson RS. Simplified technique to measure mandibular range of motion. J Prosthet Dent I996;75:56.

Rodenstein DO. Assessment of uvulopalatopharyngoplasty for treatment of sleep apnea syndrome. Sleep 1992;15:56.

Shepard JW Jr, Olsen KD. Uvulopalatopharyngoplasty for treatment of obstructive sleep apnea. Mayo Clin Proc 1990;65:1260.

Slier AH, Schcchtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996; 19:156.

Thornton WK, Roberts DH. Nonsurgical management of the obstructive sleep apnea patient. J Oral Maxillofac Surg 1996:1103.

Waldhorn RE. Sleep apnea syndrome. Am Fam Physician 1985;32:149.

Young T, Palta M, Dempsey J, ct al. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328:I230.

Facial Prosthesis Fabrication: Technical Aspects

o Carl J. Andres, DDS, MSD o

Steven R Haug, DDS, MSD

The fabrication of an extraoral facial prosthesis is as much an art as it is a science. Prosthesis form, coloration, and texture must be as indiscernible as possible from the surrounding natural tissues. The ideally constructed prosthesis must duplicate the missing facial features so precisely that the casual observer notices nothing that would draw attention to the prosthetic reconstruction. Rehabilitation efforts can only be successful when patients can appear in public without fear of attracting unwanted attention (Pig 16-1).

The construction of facial prostheses consists of four stages, each equally important to the success of the rehabilitation effort and each requiring extraordinary attention to detail: *(1)* moulage impression and working-cast fabrication, (2) sculpture and formation of the pattern, *(3)* mold fabrication, and *(4)* processing of the prosthesis material with intrinsic and extrinsic coloration.

The Moulage Impression and Working-Cast Fabrication

The first stage of prosthesis fabrication is obtaining a working cast from which the prosthesis pattern is developed and that subsequently becomes part of the mold in which the prosthesis material is polymerized. The working cast is prepared from an impression of the normal tissues surrounding the defect site and of the defect itself. Several materials have been used to obtain the moulage impression, including plaster, reversible hydrocolloid, irreversible hydrocolloid or alginate, and elastomeric materials such as polyvinvlsiloxane and polysulfide rubber. The material chosen depends in part on the size and location of the defect and in part on the preference of the operator. Reversible hydrocolloid has been used because it can be applied to the skin in thin layers with a brush, it can impress large areas, and it can accurately reproduce fine detail. The disadvantages include preparation time for liquefying the gel and the relatively hot temperature at time of application. In addition, the material tears easily and can be distorted during removal from undercut areas. Elastomeric impression materials, especially lightbodied polyvinylsiloxane, show excellent detail reproduction, high tear resistance, and good flow properties. Disadvantages include relatively short working time, difficulty mixing large quantities for impressing extensive defects, and relatively high cost. The elastomeric materials are excellent for small defects and relatively flat surfaces, such as an auricular defect. The introduction of these materials in automix cartridges has greatly facilitated their use in making facial impressions.

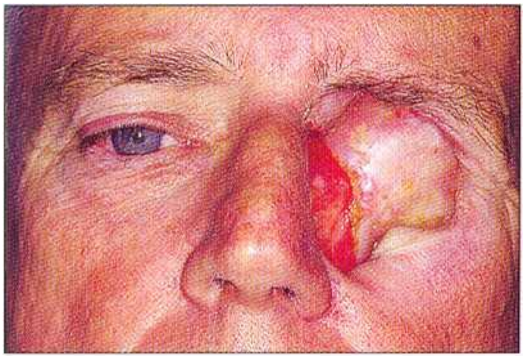


Fig 16-la Patient with orbital surgical defect.

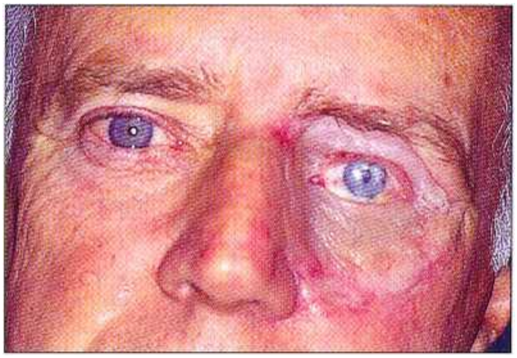


Fig 16-lb Successful facial prosthesis gives the patient confidence to function in society.

Irreversible hydrocolloid, or alginate, is used more frequently because it is readily available in the dental office, inexpensive, has long shelf life, good detail reproduction, and satisfactory physical properties. When mixed with cold water, working time is adequate tor use with large as well as small defects. The disadvantages include possible entrapment of air during application to the delect area and the possibility for distortion or tearing during removal from large undercuts. The use of cold water to prolong setting time may cause discomfort for some patients, especially in sensitive areas of the defect such as nasal mucosa.

The technique for making the moulage impression is similar for all types of impression materials with the exception of the application of the material itself. Reversible hydrocolloid is usually applied with a brush; elastomeric materials are usually ejected onto the skin from a syringe or automixing device; and alginate is usually applied with a mixing spatula but may be ejected from a syringe in certain situations, such as making an impression of a normal ear for use as a sculpting model.

The patient must be prepared for the impression procedure both physically and mentally. Physical preparation consists of adequate drapes to prevent material from getting on clothes and to confine the material to the desired area. Mental preparation may be more difficult. Some patients describe the experience as similar to a mud pack or herbal wrap experienced in a salon or spa. Patients who have never experienced skin treatments of that nature should be told that the first layer of material will be very cold but will warm rapidly to their skin temperature. Then a second layer (fast-set plaster) will feel heavier when applied and will release heat as it sets. Patients should be reassured that neither temperature extreme will cause them harm, but it may not be comfortable. Patients should be questioned about a history of claustrophobia (fear of confined spaces) and achluophobia (fear of darkness) and their concerns discussed. Some patients may become severely distressed, especially during a full facial moulage impression. In any case, patients should be constantly reassured during the impression procedure, and if a spouse, relative, or companion is present, patients are sometimes more comfortable if they are holding their hand.

The armamentarium required for the impression should be assembled prior to the procedure. For an alginate impression we recommend the following:

- Petroleum jelly
- Alginate powder (three preweighed packages or 75 grams)
- Cold water (four three-scoop measures)
- Four large flexible mixing bowls and/or quart-size vacuum mixer

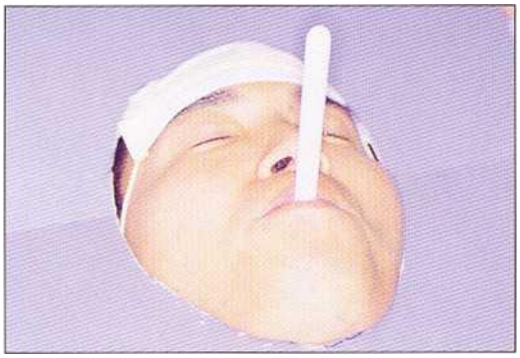


Fig 16-2 Cardboard barrier in place with cutout exposing area to be impressed. (Photo courtesy of Dr Walter W. Lim.)

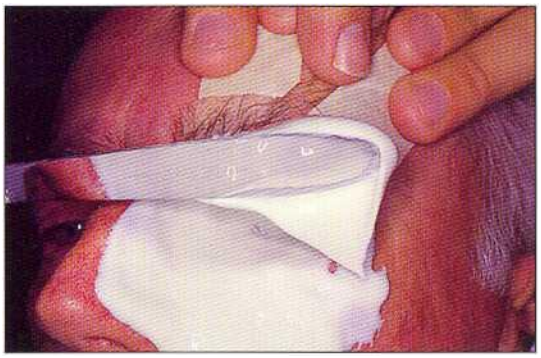


Fig 16-3 Alginate impression material is applied to the impression area with a round-end spatula.

- Four mixing spatulas
- Fast-set plaster
- Gauze squares opened to single thickness and/or alginate adhesive/spray/brush
- Patient drapes
- Breathing tube (disposable high-volume evacuator tip)
- Boxing wax
- Posterboard
- Spool of solid core lead solder (or similar dead-soft wire)

The patient is draped with hospital towels and/or a dressing gown. Hair may be protected by fastening a towel around the head covering the hairline, or a disposable surgical cap may be used. Facial hair (eyebrows, mustache, etc) is protected by a light application of petroleum jelly. A ring of boxing wax may be built around the area to be impressed, or a custom barrier may be made of cardboard. A length of solid-core lead solder may be used to define the shape of the patient’s face. This is then placed on a piece of cardboard approximately 12 X 16 inches and the outline cut out with scissors. The opening is then placed over the patient’s face, forming an effective barrier against undesirable flow of the alginate material. The cardboard may be bent to extend the impression, such as to the tragus of the ears (Fig 16-2). The patient should be positioned to minimize the effects of gravity on the peri-defect tissue. It is difficult, if not impossible, to contain the flow of the impression materials with the patient fully upright, so the position is usually halfway between upright and supine.

When all drapes and protective materials are applied, the patient should be allowed to practice breathing through the evacuator tube to ensure that adequate ventilation can be maintained. Caution the patient about hyperventilation. If the patient has difficulty breathing through the mouth, tie dental floss around cotton balls large enough to plug the nostrils without distorting them. Allow the floss to drape under the breathing tube. When the patient is breathing comfortably through the tube, the alginate material may be mixed. A water/powder ratio from 1.25 to 1.5 times the normal amount of water is used to adjust the flow properties. The material may be mixed by hand in large flexible bowls or mechanically mixed with a vacuum spatulator. The vacuum mix is much creamier than the hand- spatulated mix.

After mixing, the alginate is applied to the skin surface with a round-end mixing spatula, taking care to avoid air entrapment. A smooth, thin layer is applied over the entire impression area, much like applying frosting on a cake (Fig 16-3). When the area is covered, the opened gauze squares are applied over the entire surface using light pressure to imbed some of the gauze into the alginate. This provides mechanical retention

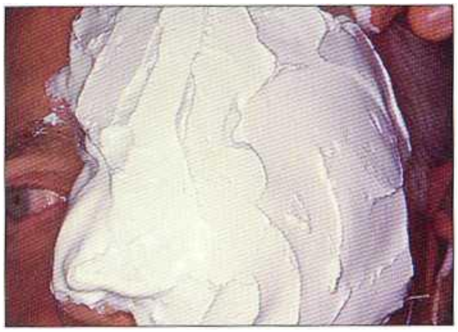


Fig 16-4 Fast-set plaster backing is applied to the impression.

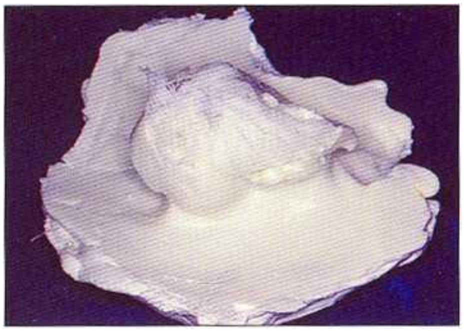


Fig 16-5 Intaglio surface of a facial moulage impression.

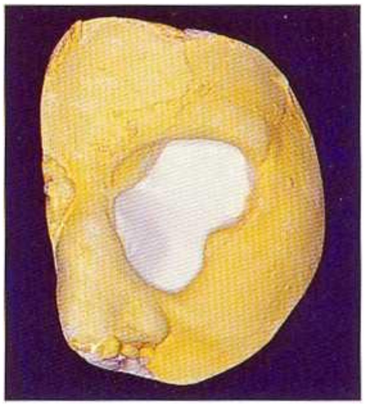


Fig 16-6 Working cast with sufficient thickness to reduce the risk of fracture during processing.

for the rigid plaster backing necessary for removal of the impression without distortion. Alginate adhesive may also be applied after the alginate has set. Care must be taken to reassure the patient throughout the procedure but especially to let the patient know that the plaster is next and will block out all light.

Mix fast-set plaster to a cake-batter consistency and spread over the entire impression surface to a thickness of about 0.25 inch. This will provide adequate strength yet minimal weight that might distort the impression on the soft tissue. A thicker ridge of reinforcement may be added at the midline (Fig 16-4). Warn the patient that as the plaster sets, heat will be given off and the impression will become quite warm. Test the plaster by tapping the surface with a blunt instrument. When the plaster is set sufficiently for removal (about 4 to 5 minutes), a tapping sound will be heard.

Grasp the impression on both sides of the patient's head and lift gently. Instruct the patient to wiggle the face, which assists in freeing the impression from the skin. Patients should also be instructed to release the breathing tube as well. The patient will usually appear flushed due to the heat and moisture from the impression, but skin color and temperature rapidly return to normal. Inspect the impression for any voids or distortion, especially the area around the defect where margins of the prosthesis will be developed (Fig 16-5). Small defects or voids not associated with the margin area may be filled in or chipped off the cast.

The impression is taken to the laboratory and poured with a suitable material for making molds. Most prosthesis elastomers in use today may be processed in dental-stone molds. Some individuals use epoxy mold materials, which require a silicone impression material. The obvious advantage of epoxy molds is strength. If not handled properly, stone molds can weaken and fracture and in some cases become contaminated with fungal growth after prolonged periods of storage. When handled properly, 5 to 10 pros- thescs may be processed in a stone mold without risk of fracture. In most clinical situations, this does not present a problem because by the time the mold has begun to deteriorate, the patient's tissues have changed enough to require a new impression. A white dental stone is preferred over other colors because it is easier to determine intensity of characterization colors during intrinsic coloring procedures. The surface of the impression should be coated with about 0.25 inch of vacuum-spatulated stone and allowed to develop an initial set. Then the remaining thickness can be poured. If the entire impression is poured all at once, the weight of the wet stone can distort the impression. The resultant working cast should have a base at least I inch thick in the deepest part of the anatomic surface of the mold (Fig 16-6).

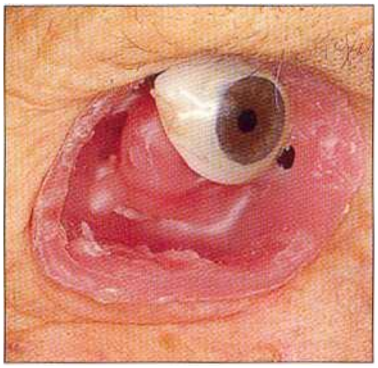


Fig 16-7 Ocular section placed on a stalk of soft wax positioned in the wax cup.

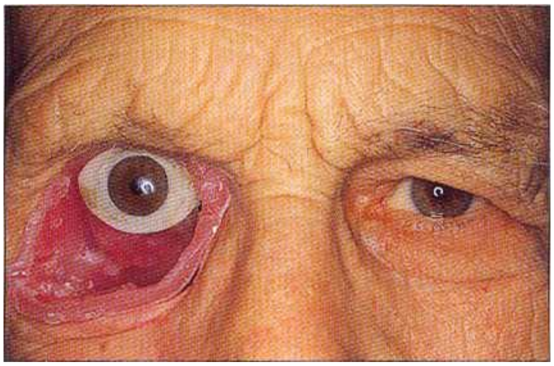


Fig 16-8 Ocular section of the facial prosthesis is positioned for correct gaze.

Sculpture and Formation of the Prosthesis Pattern

Some steps in fabrication of a prosthesis pattern, especially an orbital prosthesis, require the patient to be present during the procedure; others may be accomplished in the patient's absence.

The difficulty of forming a pattern for the final prosthesis depends upon the facial structures being replaced. An ocular prosthesis is probably the most difficult, followed by the auricular prosthesis and the nasal prosthesis. Pattern formation is a form of sculpture, and as with the sculptor, the medium or material for the sculpture is a matter of personal preference. Modeling clay and wax are the most commonly used materials. However, many individuals who once preferred sculpting clay have turned to the use of wax because of the possibility of residual oils from the clay contaminating the mold surfaces, which can interfere with the platinum catalyst employed in modern silicone prosthesis materials. A suitable wax formula of soft sculpting wax for pattern fabrication consists of melting and mixing together in a wax pot two sheets of beeswax, one sheet of hard pink baseplate wax, and two strips of clear rope boxing wax. The resultant wax is pliable enough to form into small shapes with fingers when warm yet stiff enough to carve with an instrument when chilled. The wax may be tinted with dry earth pigments to form skin color as well.

After the working cast has been trimmed, defect undercuts blocked out, and a suitable separator such as tin-foil substitute applied to the defect area, a sheet of pink baseplate wax is softened and adapted to the orbital defect. This cuplike pattern forms the basis for positioning the ocular section of the prosthesis within the defect in the same frontal, sagittal, and horizontal planes as the normal eye. This positioning is best accomplished by placing the ocular section on a stalk of soft wax in the wax cup (Fig 16-7). The assembly is placed into the orbital defect and the ocular section manipulated into the position that matches the gaze of the normal eye when the patient is staring directly at a point at eye level at least 6 feet away (Fig 16-8). The patient should be standing or sitting upright without head support when evaluating ocular position. If a bright penlight is held at eye level and the patient looks directly at the light, a reflection of the light is visible in the center of the pupil of the natural eye. The ocular section should be positioned to provide the same reflection. After the ocular section has been properly positioned, the eyelid aperture is established by softening and placing two small strips of wax over the ocular section. The shape of the lid opening should reproduce the opening of the normal eye.

Computer imaging may be used to assist establishment of the correct ocular positioning and lid opening. Using a digital camera, an image of the patient is made at a known object-lens dis-

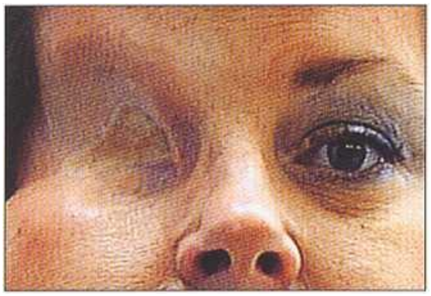


Fig 16-9a Image-editing software image of nondefect and defect sides.

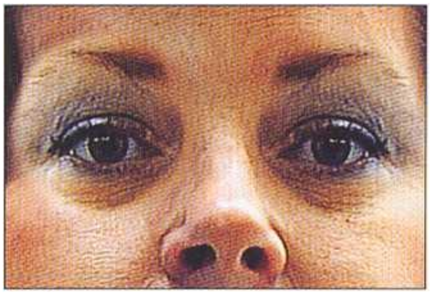


Fig 16-9b Image of normal eye reversed and superimposed over defect.

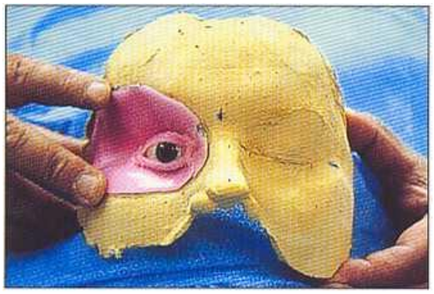
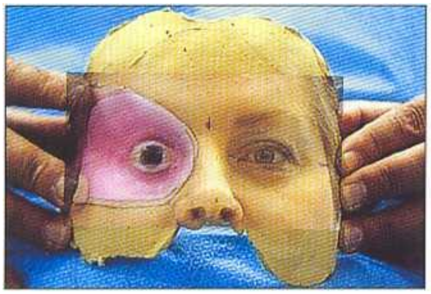


Fig 16-10 Image of the defect side with wax pattern.



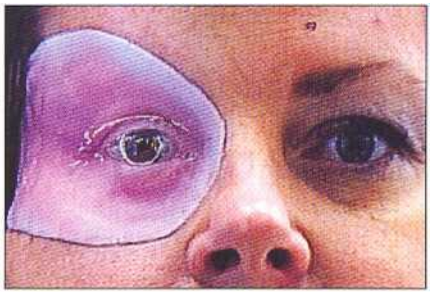


Fig 16-1 la (*left*) Superimposed image of the nondefect side over the orbital prosthesis to verify ocular and eyelid positioning.

Fig 16-1 lb *(right)* A highlighting mechanism is used to make discrepancies more visible.

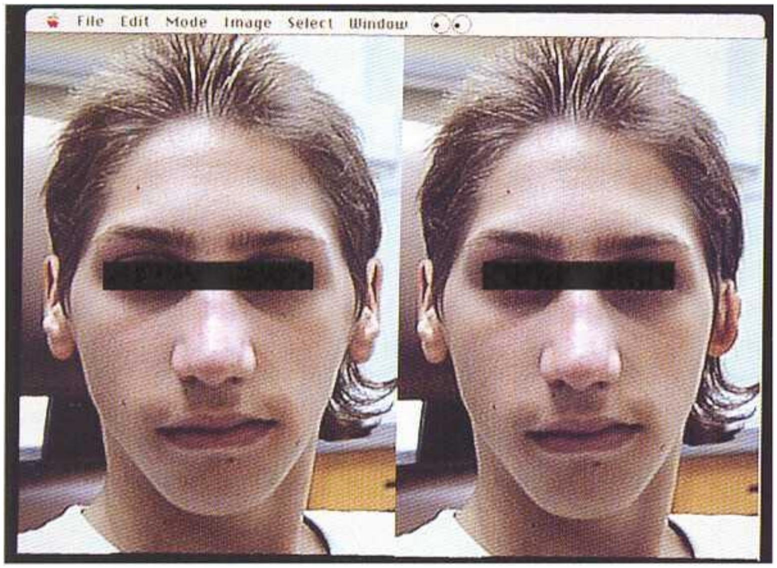


Fig 16-12 Image-editing software is used to verify the wax pattern for an auricular prosthesis. (Image-editing photos courtesy of Dr Donald Schmitt.)

ranee. Using image-editing software such as Adobe PhotoShop, the normal eye can be reversed and superimposed over the orbital defect (Fig 16-9). A similar image is made of the working cast at the same object-lens distance with the ocular segment positioned in the wax cup (Fig 16-10). Simple cut and paste operations allow the image of the actual eye to be superimposed over the orbital prosthesis to verify the ocular and eyelid positioning (Fig 16-11). The same procedure may be used to verify size, shape, and position of an auricular prosthesis (Fig 16-12).

Once the correct positioning of the ocular section has been accomplished and the eyelid aperture established, the soft sculpting-wax mixture is added with a glass eyedropper or spatula

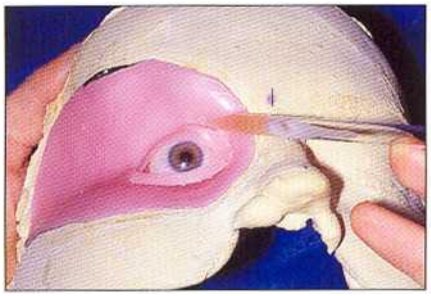


Fig 16-13 Soft sculpting wax is added to the rough contour of the prosthesis.

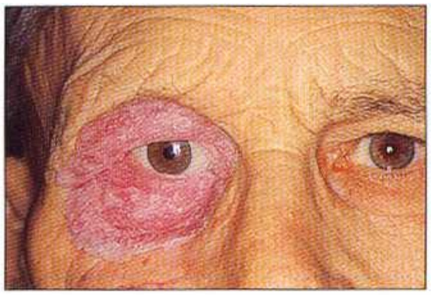


Fig 16-14 Prosthesis pattern for aged patient with skin wrinkles.

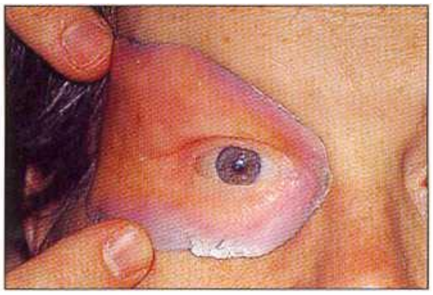


Fig 1 6-15 Final wax pattern ready for mold making.

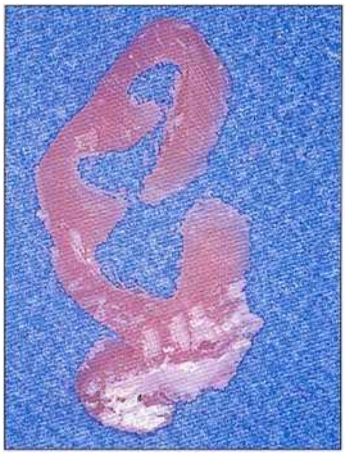
to roughly fill the remaining contour of the prosthesis out to the area where margins are to be established (Fig 16-13). At this point, the final surface contour and skin texture are established by carving in lines and wrinkles observed around the normal eye. Skin texture is age dependent, but in most instances pressing a wet gauze square into softened wax will produce a texture similar to the skin surface. The skin texture and characteristics of elderly patients with many wrinkles are much easier to reproduce than a youthful smooth skin texture (Fig 16-14).

Following completion of the fine details in the pattern, the sculpture should be placed onto the patient and verified for fit, direction of gaze, and eyelid aperture. When satisfied with the result, the pattern is ready for making the mold (Fig 16-15).

Sculpture of patterns for auricular prostheses can be difficult due to the multiple convolutions and contours of the ear. In addition, the positioning of the pattern is critical in relating it to the normal ear. Most individuals use a system of markings superiorly, inferiorly, anteriorly, and posteriorly at the time of making the impression. An ear-bow style of face-bow may be helpful in locating the marks in the horizontal and vertical planes. Marks are placed in the same positions around the normal ear using water-soluble ink. The marks are reproduced in the impression material and transferred to the resultant stone cast. A wax base is adapted to the cast of the defect and a pattern is constructed that duplicates the patient's normal car as closely as possible. Patterns for auricular prostheses have been fabricated using laser stereolithography and other CAD- CAM methods, but most individuals continue to sculpt patterns modeled after a cast of the normal car. If the ear defect is bilateral, a sibling or another individual of similar age and build may be used as an ear model. Impressions are made of the model's ear and poured in wax instead of stone. The resultant pattern is nearly complete with the exception of sealing down to the patient's working casts. Some practitioners have developed a bank of models from previous patients. Occasionally, a new patient presents with an ear similar to one in the bank, and the pattern creation becomes much easier.

An ingenious method for arriving at a basic framework for an ear sculpture was developed by Dr Sarkis Isikbav. A wax cast of an impression of the normal ear is sliced with a wax saw into 1-mm-thick sections. Each section is reversed and placed on top of the previous section, resulting in a mirror image of the original pattern (Fig 16-16). The edges are coalesced with a heated wax spatula and the framework modified to reproduce tissue detail and original size.

Nasal prostheses allow for a great deal of artistic license in pattern development. Unlike bilateral structures where one must strive to reproduce every minute detail of contralateral structures, the nose can be made to look any way the patient desires. Probably the easiest way to fabricate a nasal prosthesis pattern is to obtain an impression from a sibling or other relative with a



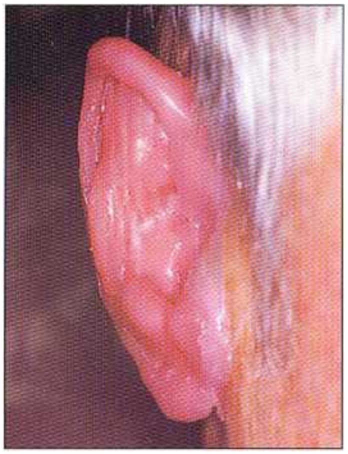


Fig 16- 16a (*left*) Wax cast of ear sectioned into **1-** mm slices with wax saw.

Fig 16-I6b *(right)* Basic framework for an ear sculpture developed from reversed sections of a model ear. (Photos courtesy of Dr Sarkis Isikbay.)

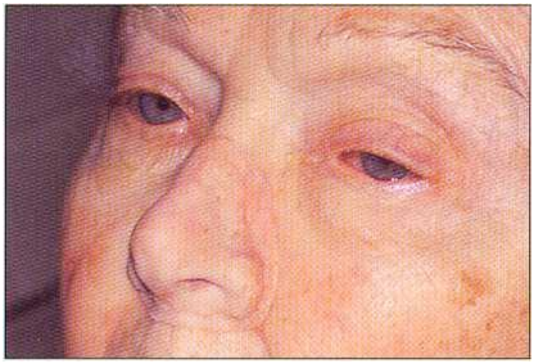


Fig 16-17 Nasal prosthesis developed from an impression of a model nose. (Photo courtesy of Dr Gary Plymale.)

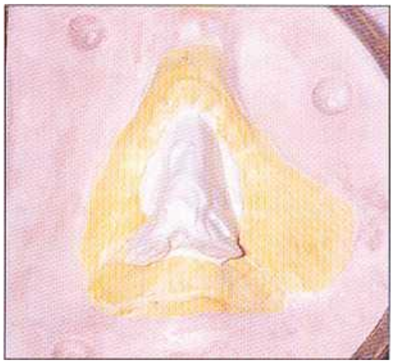


Fig 16-18 Blockout placed directly on the master cast prior to wax pattern fabrication.

strong family resemblance and pour the impression in soft sculpting wax (Fig 16-17). The prosthesis pattern is built to the desired thickness in wax and sealed to the master cast. A mix of dental stone is vibrated into the cavity between the pattern and the master cast to provide for a hollow prosthesis, allowing tor decreased prosthesis weight and an airway. If the practitioner elects to sculpt a nasal prosthesis pattern, the defect area of the working cast must be modified with a stone or plaster blockout to allow the final prosthesis to be hollow and provide an airway. The internal and external margins of the prosthesis are determined and marked on the cast. A pyramid-shaped blockout is then built on the cast and trimmed with a sharp scalpel to a configuration that will not interfere with pattern sculpture (Fig 16-18). The buildup is then coated with a suitable separating agent and the pattern wax mixture is applied and built up to a rough contour. The rough pattern may then be sculpted into the final form. After skin texture is incorporated, the pattern may be tried on the patient to verify fit and contour.

With any type of prosthesis, after the shape, size, contour, fit, and surface texture of the pattern have been verified on the patient and determined to be acceptable to both patient and practitioner (and family members or other social support group if available), the next step is fabrication of a mold to reproduce the wax pattern in the selected prosthetic material.

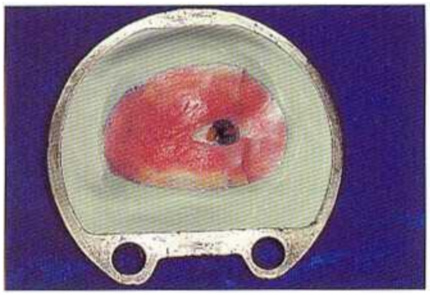


Fig 16-19 Facial prosthesis pattern flasked in a brass denture flask.

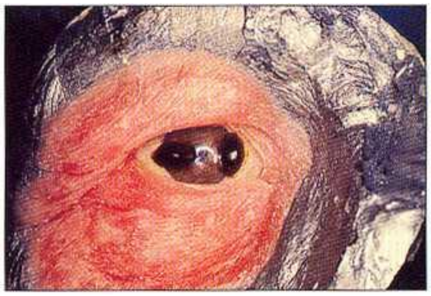


Fig 16-20 Orientation pyramids are placed on the surface of the ocular segment.

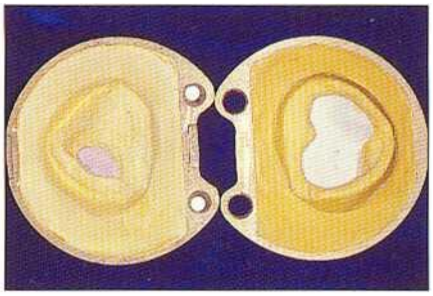


Fig 16-21 Duplicate ocular segment is luted to the cope with cyanoacrylate.

Fabrication of the Mold

Usually, the working cast is used as the tissue surface of the mold. Most small defects, such as nasal, orbital, or auricular, may be flasked in a conventional denture flask or Little Giant flask (Fig 16-19). The complete mold may be removed from the brass flask, marked with the serial number of the flask, stored, and returned to the flask for remakes of the prosthesis. In the case of large combination defects, freestanding stone molds may be employed or large-diameter PVC pipe sections may be used as casings for the molds.

In many cases, the master working cast is duplicated and the duplicate cast is used for the mold construction, thus preserving the master cast for future use in ease of fracture of the mold. This may be accomplished using reversible hydrocolloid duplicating material or irreversible hv- drocolloid impression material. The duplicating impression is poured using a suitable preweighed and vacuum-mixed stone to provide maximum physical properties. When a polyurethane lining material is to be employed, a second duplicate cast must be prepared to vacuum adapt the liner material. This cast must incorporate nylon monofilament fibers to allow more efficient air transfer during the vacuum-forming procedure. After the pattern has been sealed to the original or duplicate cast, the pattern and cast arc invested in the drag (base portion) of whatever mold carrier fits the situation: conventional denture flask, Little Giant, PVC pipe section, or freestanding stone mold.

After the stone flasking material has set in the tissue-surface half of the mold, a suitable separating medium is applied to the exposed stone surrounding the pattern. Foil substitute is the separator of choice because it is least likely to contaminate the platinum catalyst of the silicone prosthesis material. Then the cope or second part of the mold carrier is placed into position and the second pour of the mold is made over the drag, incorporating the pattern in the mold.

There are two exceptions to this procedure, the orbital prosthesis and the auricular prosthesis. For the orbital prosthesis, an indexing method must be applied to position the ocular segment of the prosthesis, now incorporated in the wax pattern, back into the mold in its same orientation as in the pattern. With the auricular prosthesis, the mold is usually constructed in three parts to allow removal of the prosthesis from the mold without tearing thin, convoluted areas. Prior to investing the orbital prosthesis pattern, an index in the form of horizontal and vertical pyramids is placed on the surface of the ocular segment with sticky wax (Fig 16-20). This index is reproduced in the cope segment of the mold. The cope is carefully removed from the drag to avoid damaging the indexing wax. Then the ocular segment is removed from the wax pattern and duplicated using an alginate impression. The duplicate ocular segment, including indexing wax, is poured in dental stone and placed into the, index indentations in the cope with cyanoacrylate adhesive (Fig 16-21). This segment will form a pocket in the final silicone prosthesis for insertion of the ocular segment of the prosthesis.

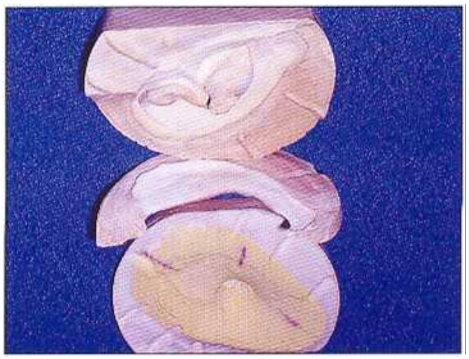


Fig 16-22 Three-piece mold for auricular prosthesis. (Photo courtesy of Dr Gary Plymale.)

Due to the thin, convoluted nature of the auricular prosthesis and the large undercut area behind the helix, it is necessary to construct a three- part mold to ensure separation of the silicone prosthesis from the mold without tearing. Prior to investing the cope, indentations are placed in the surface of the drag portion to ensure proper placement of the second part of the three-piece mold. Then a mixture of stone is prepared and placed from the surface of the drag to the height of contour of the helix around the entire posterior segment of the ear. After the stone has set, tin-foil substitute is applied and the cope section of the mold is poured (Fig 16-22).

In most instances, the heat released from the setting reaction of the dental stone will eliminate the need to boil out the wax pattern. As soon as the stone has set, the cope and drag are carefully separated, and the softened wax pattern is removed from the mold, leaving the mold surface relatively free of wax residue. Boiling water and detergent are used to clean the mold cavity. The hot mold is then coated with tin-foil substitute in preparation for placing the prosthesis material in the mold cavity. Use of tin-foil substitute as the separator leaves a smooth, velvety finish on the surface of the prosthesis. If a more distinct, shiny surface texture is desired, an acrylic floor wax may be used to seal the mold surface. The resultant prosthesis will have a shinier surface but may be more difficult to separate from the mold unless a silicone mold release agent is used.

Processing of the Prosthesis Material with Intrinsic and Extrinsic Coloration

Even when the contours of the prosthesis are not exact duplicates of the contralateral structures and the skin texture is not exactly reproduced, the prosthesis will probably remain undetectable if the coloration is correct under most lighting conditions. A more scientific method of reproducing skin color for a facial prosthesis is discussed in Chapter 17. There are probably as many methods for intrinsic and extrinsic coloration of silicone materials as there are practitioners, which is not surprising considering maxillofacial prosthetics is to a large extent an art form. Some individuals use micro air-spray techniques to color the surface of the mold. Others use a brush in technique or no distinctive intrinsic color, relying on external coloring techniques only. Again, the method of coloring is largely at the discretion of the artist.

The technique we employ is primitive compared to some devised by those artists proficient with an airbrush, but when properly executed provides predictable results. The mold cavity is prepared by coating the external tissue surface area with a thin coat of catalyzed uncolored silicone material (MDX 4-4210, Dow Corning, Midland, MI; or A2186, Factor II, Lakeside, AZ). A commercial-grade hair dryer is used to partially polymerize the first clear layer. Then characterization colors are chosen and mixed with the sili

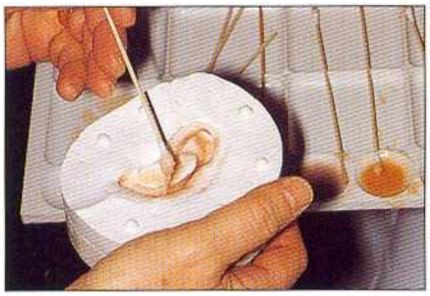


Fig 16-23 Intrinsic characterization colors are placed into the mold.

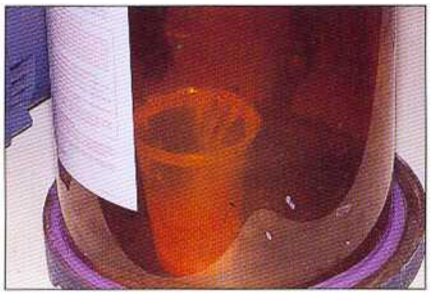


Fig 16-24 Catalyzed colored silicone material subjected to vacuum in bell jar to remove air trapped during mixing.

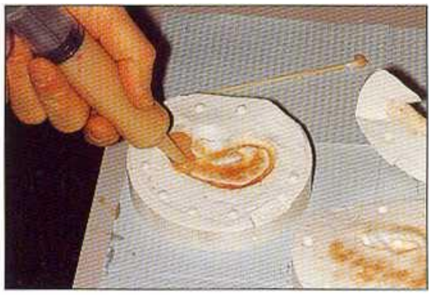


Fig 16-25 Base-color silicone material is placed into the mold space.

cone polymer and painted on the surface of the clear layer (Fig 16-23). Colored rayon fibers may be sprinkled into the mold to simulate microvasculature, but these fibers lose most of their color in less than 6 months and are the least color stable of the pigments used to characterize prostheses.

If a urethane lining is to be used for the prosthesis, the urethane sheet (Factor II) is cut to size and clamped into the frame of a vacuforming device. The sheet is cleaned with reagent-grade acetone and allowed to dry for 20 minutes. The urethane sheet is then heated and vacuum adapted to the cast. One thin coat of 304 primer (Dow Corning) is applied with a plastic-handled cotton-tip applicator and allowed to dry for 30 minutes. A thin layer of A-320 bonding enhancer (Factor II) is then applied and allowed to dry for 20 minutes. The mold is then packed with the silicone material of choice and placed in a dry-heat oven at room temperature. The oven is brought to 150°F and held for 90 minutes, then elevated to 200°F for an additional 20 minutes, removed from the oven, and allowed to bench cool before opening.

After the mold surface is characterized by localized application of color, a base color mixture of the silicone material is prepared to fill the mold cavity. Although dry earth pigments are the most color stable, artist’s oil pigments, rayon fibers, silicone paste pigment, or liquid makeup can be used to provide color and kaolin powder to provide opacity to the mixture. When a satisfactory base color has been mixed, the silicone catalyst is added, and air may be removed from the mixture by placing the container in a bell jar under vacuum. As the air incorporated by stirring is released, the material will foam. To avoid spillover, a container seven times the volume of the silicone must be used (Fig 16-24). In many cases this is impractical, and the vacuum must be released to avoid spillage over the top of the container. The sudden increase in atmospheric pressure breaks the foam bubble and releases trapped air. This cycle is repeated until foaming is minimal.

The colored, catalyzed, air-less silicone is then placed into the mold cavity', taking care to allow the liquid to flow into all thin areas, particularly in the auricular prosthesis mold (Fig 16-25). If both mold surfaces are concave, the concavities should both be filled with silicone. If one surface is concave and the other convex, as in a nasal prosthesis mold, only the concave mold surface must be filled with silicone. The two pieces are reassembled and excess silicone is expressed using light pressure until maximum mold closure is achieved. The mold is then clamped and placed into a dry-heat oven at the manufacturer’s prescribed polymerization time and temperature.

Residual silicone may be left on the external surface of the mold to test for complete polymerization. Improperly polymerized silicone will remain sticky on the surface. After the polymerization cycle is complete, the mold should be allowed to cool to room temperature before removing the completed prosthesis. The residual flash may be trimmed back to the margin with sharp scissors or a scalpel and finished with an abrasive stone. The prosthesis should be cleaned

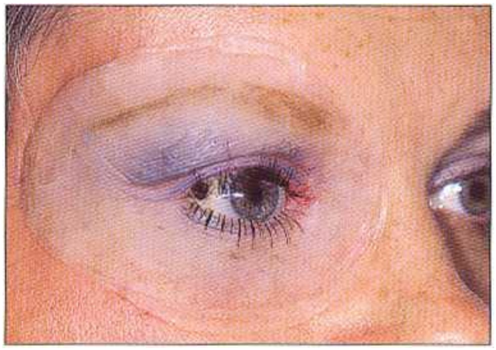


Fig 16-26 Completed urethane-lined silicone prosthesis for patient shown in Fig 16-9.

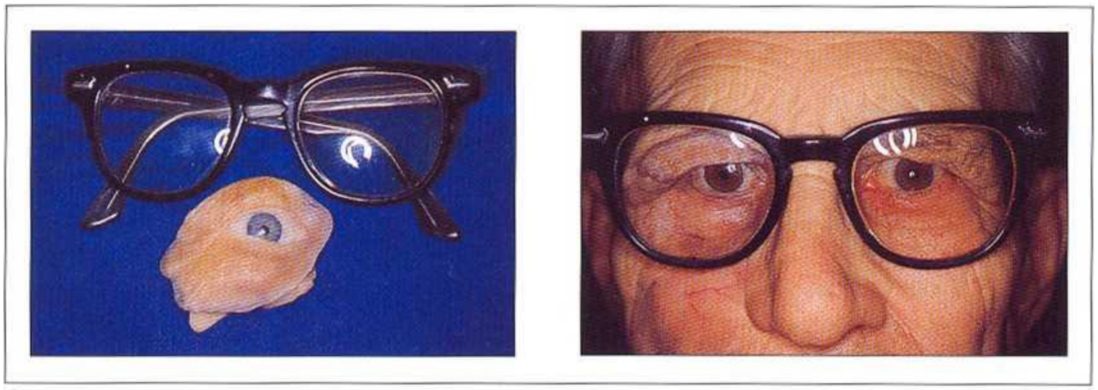


Fig 16-27a *(left)* Completed orbital prosthesis for patient shown in Figs 16-7 and 16-8 with eyeglass frames selected to assist in concealing margins.

Fig 16-27b *(right)* Prosthesis and eyeglasses immediately after placement.

with water and mild detergent before placement on the patient. Extrinsic coloration of the silicone prosthesis is difficult and should be avoided if possible. If it is necessary to add color to the surface, silicone medical adhesive Type A (Dow- Coming) is a suitable carrier for the pigment. Pigment is mixed with the silicone adhesive and applied to the surface of the prosthesis with a fingertip in a patting motion. This allows a buildup of color intensity as needed, without destroying surface texture. The adhesive begins to set on exposure to moisture in the air, releasing acetic acid through evaporation. After the desired color is obtained, a damp gauze square is pressed into the added silicone adhesive. The gauze filaments will assist in returning the desired surface texture and provide moisture to catalyze the polymerization reaction. The process may be shortened by placing the prosthesis in a microwave oven for 10 to 15 minutes.

Patients should be instructed in the use and care of the prosthesis, including instruction on how to orient and place it, how to use adhesives, and how to maintain both tissue and prosthesis hygiene. Additionally, patients should be advised that the color match depends on the color of their tissues, which may be susceptible to the seasons as well as activity level and environmental temperatures (Figs 16-26 and 16-27).

Summary

This chapter has described the four steps required for the fabrication of facial prosthcscs. While numerous variations in technique are possible, the basic steps described here are standard to most.

Facial Prosthesis Fabrication: Coloration Techniques

o Rosemary Seelaus, BS, MAMS

o Randall J.Troppmann, BFA

Accurate representation of skin color in a facial prosthesis is essential to achieving a successful esthetic result, yet it remains one of the greatest challenges faced by the clinician (Ma et al, 1988; Bergstrom, 1998). Creating a facial prosthesis that appears to have a realistic skin surface while achieving seamless visual integration with the surrounding tissue requires both artistic and technical expertise. The ability to match skin tones effectively requires a keen eye, a good understanding of color theory and application, meticulous attention to detail, practice, and perseverance. Historically, lack of these attributes has limited the consistency of prosthetic outcomes. Many approaches and techniques exist that attempt to achieve an accurate skin color match, including trial-and-error mixing, shade guides, pigment dispersion systems, and color measurement using a colorimeter or spectrophotometer. This chapter describes techniques for coloring silicone elastomer to achieve a realistic appearance in the fabrication of an auricular prosthesis using traditional trial-and-error methods, spectrophotometry, and computerized color formulation. One should keep in mind that techniques often vary based on the type of prosthesis being fabricated (ie, auricular, orbital, or nasal). The coloring techniques discussed in this chapter provide the reader with a practical approach to color matching for facial prostheses.

Background

Several components contribute to the overall color and characterization of facial prostheses. These include pigment, rayon flock, thread or yarn, and kaolin. Achieving realistic skin color, texture, translucency, and heterogeneity requires careful balance of these components. Each component is added to the facial prosthetic material until the mixture matches the target skin color and mimics its characteristics. This is performed in accordance with the techniques described in this chapter. While techniques vary as to when and how color is applied to the prosthesis, effective coloration employs both intrinsic and extrinsic coloring.

Intrinsic coloration is color applied within the mold during the casting procedure. This allows one to simulate the laminar structure of skin. Depth of color and translucency can be more accurately achieved through intrinsic techniques. A realistic three-dimensional quality' is accomplished by incorporating subsurface details such as blood vessels, freckles, and moles that enhance the overall esthetic result. Coloring intrinsically has functional advantages as well. It increases the service life of the prosthesis since the coloring is less vulnerable to environmental conditions and handling, and it does not interfere with sculpted surface texture or planned translucency, which

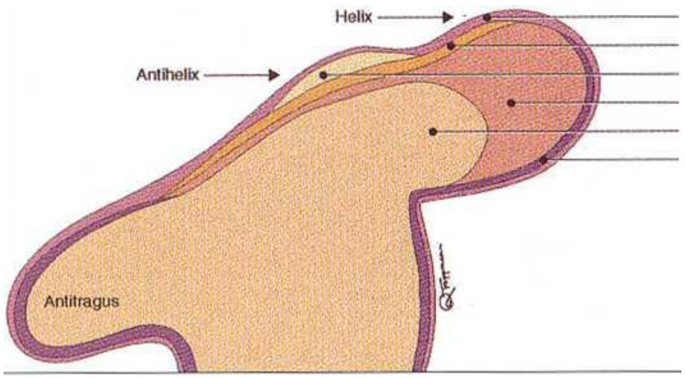


Fig 17-1 Cross section of auricular prosthesis with intrinsic laminar glazes.

are often compromised by the application of extrinsic color.

Extrinsic coloration is color applied to the surface of a prosthesis that has been cured and removed from the mold. Though extrinsic coloration is more predictable and can be evaluated in direct comparison with the patient's skin, it should be used sparingly due to its vulnerability to environmental conditions and handling. One should attempt to perform the majority' of coloration through intrinsic techniques due to the advantages outlined above (Fig 17-1).

Color Concepts

A basic understanding of color theory terminology will assist the reader in discussion of the techniques presented. The following are terms commonly used to describe attributes of color and color mixtures.

Hue—The attribute of color perception by means of which an object is judged to be red, yellow, green, blue, purple, and so forth. Often described as "the color" (Hunter and Harold, 1987). Example: A sunflower is yellow, a tomato is red, the grass is green.

Value—The relative lightness or darkness of a color. Example: The images that appear on a black-and-white photograph are differentiated by value alone.

Saturation—The attribute of color perception that expresses the departure from gray of the same value (Hunter and Harold, 1987). In the Munscll color system, saturation is referred to as chroma. Example: As colored ink is dropped into a glass of water, the water becomes progressively more saturated in color as more drops of ink are added.

Opacity—The degree to which a sheet, film, or object obscures a pattern beneath or behind it.

Translucency—The degree to which light can pass through an object. Example: A soap bubble has high translucency and low opacity.

Pigment loading—The percentage of the entire weight of substrate that is pigment. Example: 100 g of pigmented silicone with 0.3 g of pigment has a pigment loading of 0.3%. As pigment loading increases, opacity increases.

These terms will be used to describe the approach and evaluation of mixing silicone and coloring components to match a particular skin tone. It is important that the clinician attempt to mimic the hue, value, saturation, and translucency of the patient's skin tone. In addressing the element of translucency, achieving the appropriate pigment loading is critical.

In addition to the terms defined above, it is also helpful to understand how primary colors

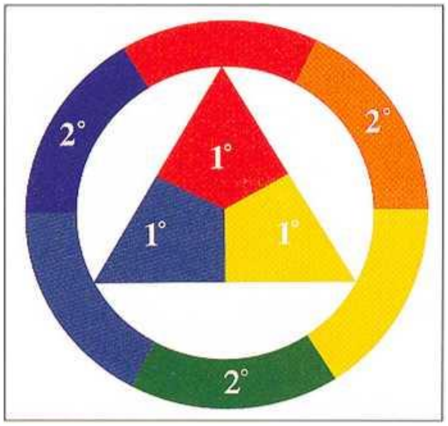


Fig 17-2 Primary (1°) and secondary (2°) colors. Colors opposite one another on the color wheel are complements of one another, eg, green is the complement of red.

Table 17-1 Primary, Secondary, and Complementary Colors

Primary colors	Secondary colors	Complementary colors
Red	red + yellow = ORANGE	RED • GREEN
Yellow	yellow + blue = GREEN	YELLOW • VIOLET
Blue	blue + red = VIOLET	BLUE • ORANGE

(red, yellow, and blue) contribute to secondary colors (orange, green, and violet). Furthermore, knowledge of primary and secondary complementary (opposite) colors is useful in addressing the element of saturation. For example, by adding the complement of a color to a mixture, one can desaturate the overall hue (Fig 17-2, Table 17-1).

Lighting Considerations

To effectively appraise attributes of color, lighting must be adequate. It is well documented that lighting conditions present considerable challenges in color matching. Proper lighting is essential for an effective color match in facial prosthetics. Where possible, full-spectrum color-corrected lights are recommended. If color-corrected lighting is not available, incandescent lighting with ample natural light may be used. Regardless of the type of lighting, intensify of light sources should be consistent. In some cases one may elect to match color in only one light source if the patient spends a substantial amount of time in an environment specific to that light source. However, a color match is best evaluated under various light sources such as daylight, fluorescent, and incandescent to reduce metamerism.

Metamerism is the effect where two colors that appear to match under one light source do not match under another. Metamerism should not be confused with color constancy, which describes the experience of an apparent color difference observed in an object when the object is illuminated by different light sources independently of the other (Hunter and Harold, 1987). Controlling the level of metamerism in facial prosthetics is challenging and unpredictable when utilizing the traditional trial-and-error mixing technique. Spectrophotometry and color formulation aid in minimizing metamerism.

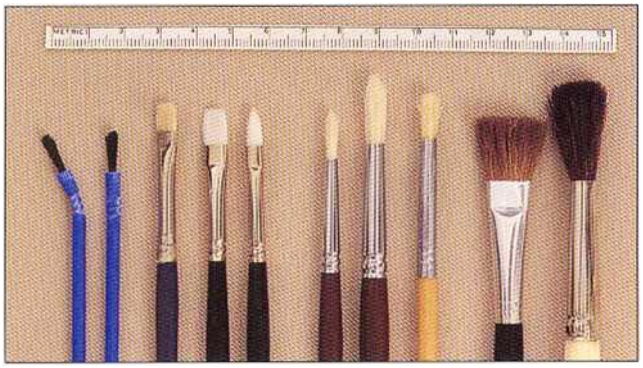


Fig 17-3 Brushes for intrinsic coloring (I), extrinsic coloring (E). and deshining (S) techniques. *Left to right:* two disposable Benda Brushes (I); two "brights" (synthetic and natural bristle) (I); one synthetic bristle “filbert" (I); three natural-bristle “rounds" (E); two sable hair brushes for kaolin and icing sugar application (S).

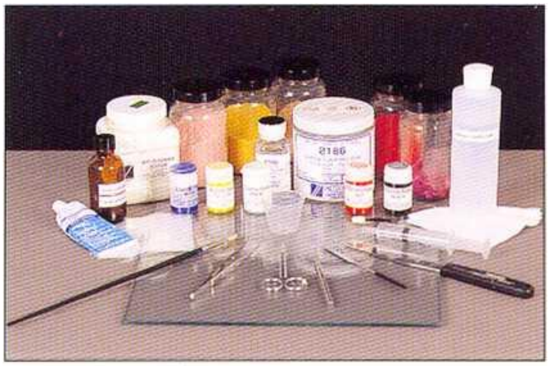


Fig 17-4 Materials and equipment required for trial- and-error color mixing.

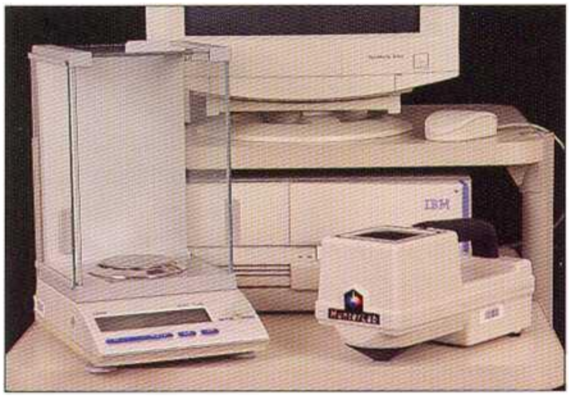


Fig 17-5 Equipment required for colorformulation color mixing.

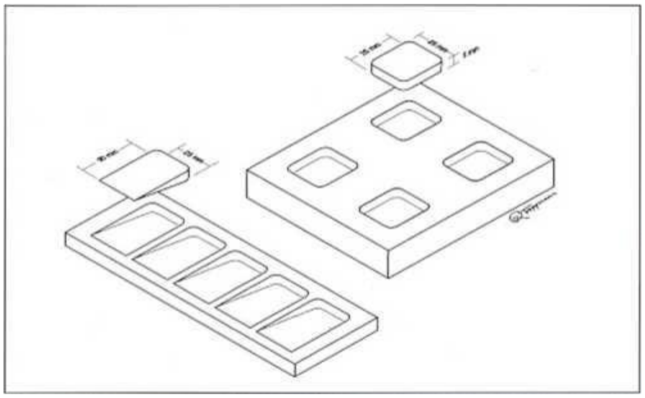


Fig 17 -6 Swatch and wedge molds for preparation of colored silicone samples.

Materials and Equipment

Materials used in coloring facial prosthetic material are varied. Those presented here are the materials we prefer. These include requirements for mixing the patient’s base color, intrinsic laminar colors, and performing intrinsic and extrinsic coloration (Figs 17-3 to 17-6). Tables 17-2 and 17-3 outline these materials, suggested manufacturers, and respective procedural applications. To date, silicone elastomer is the material of choice for fabrication of facial prosthescs due to its preferred chemical and mechanical properties and relative ease of use (Andres et al, 1992). Moreover, it is the material of choice with regard to techniques discussed in this chapter.

Table 17-2 Materials and Equipment

Item	Suggested model and manufacturer	Procedural application
Translucent, two-component room-temperature vulcanizing silicone elastomer	A-2186, fast and regular set (Factor II, Lakeside, A2)	Fabricate prosthesis
Pigments (minimum color requirements: red, blue, yellow, white, and black)*	Ferro or earth powders or paste (Factor II)	Color silicone elastomer
Flock	Rayon fiber flock: flesh, light buff, tan, brown, yellow, gold, pink, red, blue, green, and violet (Factor II)	Adjust hue and add texture to silicone elastomer
Thread or yarn	Nylon, silk, or cotton yarn; red, blue, purple, magenta (any arts and crafts store)	Simulate blood vessels intrinsically
Kaolin powder	Georgia Kaolin (Factor II)	Opaque silicone; deshine cured surface of silicone
Thixotropic agent	Thixo (Factor II)	Lower viscosity of silicone mixture
Artist's and disposable brushes of various sizes and shapes (see Fig 17-3)	Premier: SH405R #4, #2; 685 #4; 875 # 1 /4; M. Grumbacher Academy 760B #2 Bright (any art supply store) Benda Brushes (Centrix, Shelton, CT)	Intrinsic painting Extrinsic painting Application of kaolin and icing sugar
10X10-cm transparent plastic sheets	10 X 10-cm plastic sheets (Henry Schein, Port Washington, NY)	Vehicle for holding silicone mixture for comparison to patient's skin
Isopropyl alcohol	Isopropyl Alcohol 99% (Ingram & Bell Medical, Don Mills, ON)	Clean surface of prosthesis in preparation for extrinsic coloration; clean brushes and glass palette
Moisture-cure silicone	medical adhesive silicone Type A 891 (Dow Corning, Midland, Ml)	Extrinsic coloring
Trichloroethanet	1,1,1 -trichloroethane (Fischer Chemical, Fischer Scientific, Fair Lawn, NJ)	Dilute moisture-cure silicone; clean brushes
Digital balance	Mettler BB600 (Mettler-Toledo, Greifensee, Switzerland)	Weigh silicone, catalyst, pigment, and flock
Scissors	Hu Friedy S5 (Hu Friedy, Chicago, IL) Storz E-3405 (Storz, Mississauga, ON)	Cut yarn for blood vessels and tip of syringe; trim flash off cured prosthesis
Metal spatulas, small and large	Hu Friedy L2. CS24 (Hu Friedy) No. 3R Stainless (Buffalo Dental Manufacturing, Cambridge, ON)	Mix and de-air silicone
Cotton forceps, tweezers, pointed instrument	N/A	Disperse flock, yarn; place yarn for vessel simulation
A large mixing pad or glass slab palette (preferred dimension 25 cm X 25 cm X .5 cm)	Custom-cut glass palettes (Crystal Glass Canada, Edmonton, AB)	Work surface for mixing silicone
100 mL plastic cup with lid	133-mL clear polypropylene container (Fischer Scientific, Ottawa, ON)	Hold silicone mixture
30 mL plastic medication cups	30-mL plastic medication cups (Polar, Sheboygan, WI)	Hold laminar glazes
12 mL plastic syringe with curved tip and nonlatex stopper	Monject 412 curved-tip syringe (latex-free) (Sherwood Medical, St Louis, MO)	Inject catalyzed silicone into helical groove
Gauze (2 in X 2 in, 4 in X 4 in)	N/A	Clean up
Nonlatex gloves and mask	PFR 95 (Technol, Fort Worth. TX) Synthetic PF (Dash Medical Gloves, Franklin, WI)	Personal safety; prevent contamination of silicone by skin oils
De-airing device	NALGENE vacuum chamber (Nalge. Rochester, NY) Multivac S (Degussa Canada, Richmond, BC)	De-air catalyzed silicone

Table 17-2 Materials and Equipment (cont.)

Item	Suggested model and manufacturer	Procedural application
Air-circulating oven	Isotemp oven (Fischer Scientific. Ottawa, ON)	Process silicone prosthesis
The prepared flask or mould with separating medium applied	N/A	Fabricate prosthesis
Method for recording formulae	Computer or patient's chart	Ensure repeatability of color matches
Silicone trimming burs	3M Scotch-Brite dental onitized wheels (2 cm) (3M, St Paul, MN) Molloplast-Cutters (Detax, Ettlingen, Germany)	Trim excess silicone; smooth helical seam
Adequate lighting	See Lighting Considerations	Accurate color assessment
Adequate ventilation	Great Lakes Orthodontics fume controller (Great Lakes Orthodontics, Tonawanda, NY)	Safety.

*A multitude of other colors is available and can be utilized; selection is subjective. It is up to the clinician to determine which pigments are the most effective in achieving a quick and accurate color match. Other popular choices include yellow ochre, burnt umber, buff; and violet. Conservative use of black to darken the value of a mixture is recommended. Blue, violet, brown, red-brown, and green are effective in achieving a darker value; black will dull the final perceived color.

tDue to the hazards associated with prolonged use of trichloroethane 1,1, 1, we recommend the use of alternative solvents for cleaning and diluting silicone. Amtex Chemical, West Chester, PA, supplies biodegradable solvents for silicone cleaning and diluting.

Table 17-3 Additional Requirements for Computerized Color Formulation

Item	Suggested model and manufacturer	Procedural application
Handheld spectrophotometer	Miniscan XE (Hunter Laboratories, Reston, VA)	Take skin color reading
Color formulation software	Easy Match Plastics (Hunter Laboratories)	Record formulae; determine pigment formula
A 200 MHz IBM-compatible computer and SVGA monitor	N/A	Perform color formulation
Digital balance accurate to 0.0001 g	Mettler-Toledo AB104 (Mettler-Toledo, Greifensee, Switzerland)	Weigh pigments
Calibrated pigment database, calibrated with Ferro paste pigments	Easy Match Plastics (Hunter Laboratories)	Determine pigment formulae
Flask designed to prepare 25 X 25 X 5-mm silicone swatches	Custom fabricated (COMPRU, Misericordia Hospital, Edmonton, Alberta Canada)	Prepare sample color swatches for color match assessment

Table 17-4 Timeline for Traditional Versus Computerized Color-Formulation Color Matching

Technique	Appt. no.	Procedure	Approximate time required (min)
Traditional	1	Mix base color	90
	1	Mix laminar glazes	90
	2	Reassess color match; pack mold	120
	3	Extrinsic coloration	180
Computerized	1	Measure skin color with spectrophotometer	30
	N/A	Perform color formulation (lab procedure)	120
	2	Evaluate color-formulated base color and adjust if necessary	30
	2	Mix laminar glazes	90
	3	Reassess color match; pack mold	120
	4	Extrinsic coloration	180

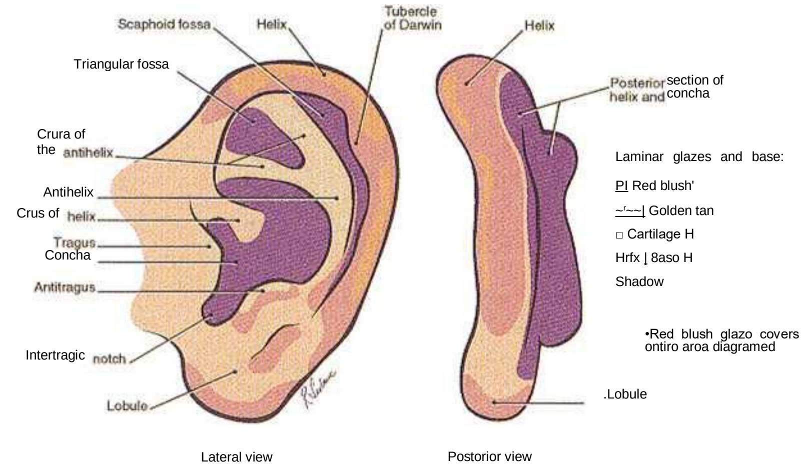
Procedure

This section describes techniques for mixing a base color using first the trial-and-error method followed by the color formulation method, intrinsic coloration using six laminar glazes, extrinsic coloration, and techniques for reducing shine.

Adequate time should be allowed to produce an accurate color match. Mixing the base color alone can easily take up to an hour for the less- experienced mixer using the traditional trial-and - error technique. The color formulation procedure of mixing a base color requires approximately 30 minutes of clinical time followed by 2 hours of laboratory time. To eliminate unnecessary time pressures while mixing, we recommend that one appointment be dedicated to mixing and evaluating color for the patient. A second opportunity to assess the color match can remedy problems of mental and visual fatigue (Roberts, 1971) (Table 17-4).

Identifying and Mixing the Base Color

The base color makes up the bulk of the prosthesis; therefore, mix ample material to fill the mold. A typical auricular prosthesis requires approximately 40 g of base material. Identifying the target base skin color can be problematic. Considering that skin is laminar, the objective is to mix the color of the underlying skin tone. Layers of color will be used to depict pink blush tones, freckling, tanned skin, highlights (cartilage), and shadows. The target base color represents the overall skin tone minus these skin characteristics and is typically one of the lightest areas of skin. Common places to identify the base color are on the underside of the forearm, along the hairline, anterior to the tragus, and at the base of the helix (Fig 17-7).



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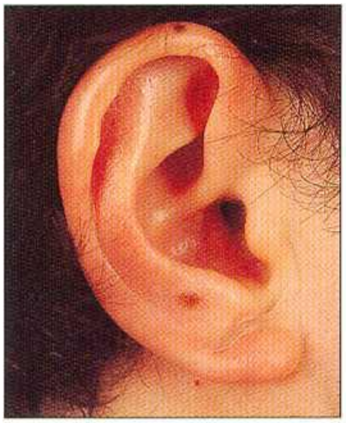

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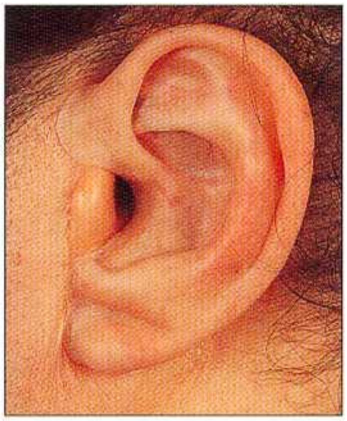

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Fig 17-7a Anatomy of the ear (lateral and posterior views) and corresponding loci for intrinsic glaze application.

Fig 17-7b Patient's ear.

Fig 17-7c Prosthetic ear colored to match contralateral ear. Base color was established using color formulation. Red flock was placed directly in the mold to create surface vasculature. the mold was created by placement of brown and tan flock directly in the mold after applying the first layer of silicone.

Traditional Trial-and-Error Method of Mixing a Base Color

One of the most common approaches to mixing color for facial prosthetics is a trial-and-error process of adding pigments in small quantities to silicone and frequently comparing the mixture to the patient's skin in an adequately lit environment. The following describes this procedure for matching color for a Caucasian auricular prosthesis.

1. Measure 40 g of silicone into a 100-mL clear plastic cup using a clean metal spatula. On a glass palette, arrange small amounts of red, blue, yellow, white, and green pigments. Pigments should be added to the silicone in conservative amounts and blended thoroughly. Judgments concerning what addi tional pigments arc required should be made only after the mixture has achieved a homogeneous appearance. As pigment is added, the opacity of the silicone mixture will increase. White pigment and kaolin are important in achieving the right opacity and value for the base color.
2. Add a small amount of white pigment to increase the opacity and value of the silicone. Kaolin can also be used in place of the white pigment, though it has far less opaqueing power.

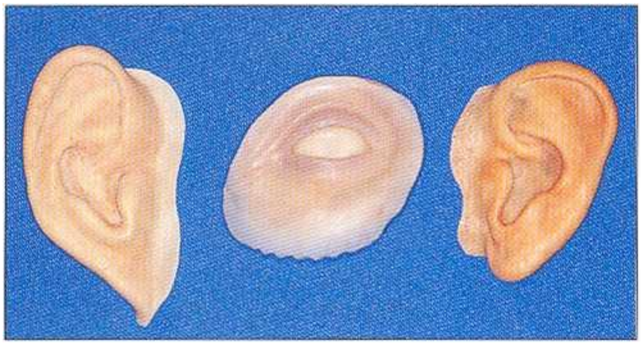


Fig 17-8 Three prostheses demonstrate attempts to achieve target opacity of the base color. *Left to right:* Base color is too opaque. Base color is too translucent. Base color with good balance of translucency and opacity.

A common pitfall is to add too much white pigment, which results in a very opaque color and subsequently produces a prosthesis that looks unnatural on the patient. Due to its powerful masking ability', white paste pigment should be used cautiously. If a color that is mixed appears too dark, adding white may make matters worse, especially if the color has already reached the target opacity. As pigments are added to correct for hue, one should always consider the subsequent effect on opacity due to a change in pigment loading (Fig 17-8).

3. To achieve a color closer to that of skin, add small amounts of red and yellow pigments. At this point the silicone will be peach in color.
4. Add a small amount of blue pigment. The addition of blue will darken the value of the silicone and desaturate it, giving it a more realistic color. If the color appears too saturated for the target skin tone, small amounts of green pigment or flock can be added to achieve a less saturated color. Since green and blue are complementary to colors in the red to orange range, green and blue can be used to desaturate a mixture that appears too bright or vivid. In reference to the Munsell color system, human skin has a chroma (saturation) between 2 and 4, which is grayer than most pigments (5 to 14) (Erb, 1995). A less saturated color will look more realistic than a fully saturated color.
5. For repeatability, pigment amounts added should be measured and recorded by weight or dropper.
6. When the color of the silicone approaches the desired base color, place a small amount of the colored silicone (approximately 2 g) in the center of a folded transparent plastic sheet. Compare the mixed silicone color with the target base color of the patient’s skin and modify as necessary.
7. Add flock to make subtle color adjustments without affecting translucency. Flock adds the appearance of texture to silicone; hence, skin with a very creamy appearance should be limited in flock content.

Evaluation of matching hue, saturation, and translucency to skin improves with experience. Requesting that a fellow clinician simultaneously evaluate the color can be helpful in determining when an acceptable skin color match has been achieved. It is also helpful to color match in a room with neutral gray walls. This eliminates visual distractions of reflected color from the surrounding environment.

Computerized Color Formulation

Spectrophotometry combined with computerized color formulation provides an objective means of achieving a skin color match through a mix-correct-corrcct procedure (Troppmann et al, 1996). This is accomplished by computing a pigment formula with color formulation software that matches a measured skin color. Skin measured with the spectrophotometer yields a spectral curve between 400 and 700 nm, the visible range of the electromagnetic spectrum. The pigment formula that is derived from the color formulation process yields a spectral curve that mimics that of the skin color measure. By establishing this fundamental spectral curve of the patient's skin color and its respective pigment formula, one can approach the color-matching process with greater precision.

Spectrophotometry and color formulation offer several advantages over traditional trial-and- error methods of color matching. First, the clinical time required for color mixing is reduced since a patient's skin can be measured using the spectrophotometer at one appointment for evaluation at a subsequent appointment. Once a skin measure is taken, the formula can be prepared in the laboratory and ready at the onset of the colormixing appointment. Second, the formula can be mixed repeatedly and accurately. Third, metamerism is minimized since the formula is established based on three different illuminants. Finally, translucency can be controlled as pigment loading is defined by the user in the color formulation software. Presently, the system requires approximately 2 hours of laboratory time to arrive at an acceptable color match. While research and development continues, we use this technique routinely.

The computerized formulation process involves selecting a color to measure, measuring the color with the spectrophotometer, transferring the measurement data to the computer, calculating and mixing a formula, evaluating the final formula, and preparing a batch of colored silicone for packing. Subjectivity is applied only in the selection of the skin area to measure and during final evaluation of the formula with the patient present. The remainder of the color formulation procedure is entirely objective.

Background information and equipment setup

A handheld spectrophotometer (MiniScan XE, Hunter Labs, Reston, VA) measures spectral reflectance in the range of400 to 700 nm. Spectral reflectance of skin is measured at 10-nm increments, which is sufficient resolution to perform color formulation (Kuehni, 1975). The view port of the spectrophotometer is 5 mm in diameter, which represents the area of skin measured, and an average value is determined. Prior to taking a skin color measurement, the spectrophotometer must be calibrated according to the manufacturer's instructions.

Initial setup of the software (Easy Match Plastics, Hunter Labs) requires a one-time procedure of calibrating a pigment database. To do this, the user prepares samples of individual pigments mixed in silicone according to predefined variable concentrations, as advised by the software manufacturer. The prepared samples are measured for color using the spectrophotometer. With the data acquired, the software figures the scattering and absorption behavior for each particular color. The pigment database must include a minimum of white, black, red, yellow, and blue pigments. Additional colors can be included in establishing the pigment database, which may broaden colormatching options. Three illuminants are selected in the color formulation software: daylight (DAS), incandescent (A), and fluorescent (F).

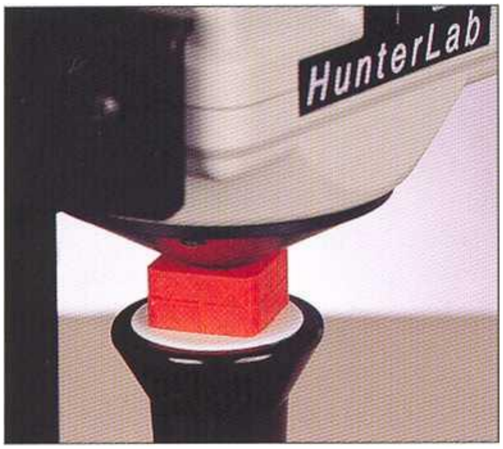
To execute a color match with the color-formulation software against measured skin color, the pigment loading, number of pigments, and batch weight must be defined.

Example-.
Pigment loading = 0.16%
Number of pigments in formula = 4
Batch weight = 22.435 g

The batch weight is the collective amount of all components within a mixture of silicone for a prosthesis.

Example-.
20 g = silicone
2 g = catalyst
0. 4 g = kaolin (a constant weight added to provide opacity.)
0. 035 g = total pigment weight

Based on the calibrated pigment database, the computer calculates all possible four-pigment combinations to find the best match under the three software-defined light sources. The resulting formula consists of weight in grams of each of the four pigments used in mixing the color. The



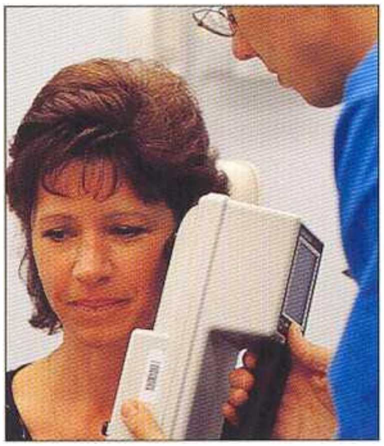


Fig 17-9 Prepared color swatch is measured **Fig 17-10** Patient skin color is mea- with spectrophotometer for comparison to orig- sured using spectrophotometer, inal color reading.

collective weight of all four pigments equals the predefined total pigment weight.

The formula is mixed and catalyzed, and a sample is created using the color-swatch preparation mold (Fig 17-6). After curing, the color swatch is measured using the spectrophotometer (Fig 17-9), stored in the computer, and then compared with the original skin color measurement to yield a Delta E value. Delta E is a numerical value of color difference used to determine required formula correction. It has been reported that with available color formulation algorithms, iterative correction is necessary to improve a color formula until the Delta E value is within an acceptable range (Ma et al, 1987). Generally a Delta E of less than 2.0 is acceptable for a base color. Clinical trials demonstrate that two corrections are required to establish an acceptable skin color match.

Clinical procedure

1. To match for a base color, select a flat, accessible area of skin on the patient.
2. Measure the skin color with the spectrophotometer. Take three readings in the area of target color. Use the average of these three readings for color formulation. The skin measurement data is stored in the color formulation software (Fig 17-10).
3. Calculate a formula of pigment weights using the formulation software.
4. Weigh pigments on the digital balance (Table 17-3) according to the formula.
5. Assess the final formula by creating a sample with a wedge mold (Fig 17-6) for comparison to the patient's skin.
6. To create the batch of base color, double the pigment formula to produce 40 grams of silicone. The following is an example of a pigment formula for 40 g of silicone elastomer for a base color: red, 0.0177 g; blue, 0.0098 g; yellow, 0.0113 g; white, 0.0176 g; kaolin, 0.4 g.
7. Mix pigments and silicone thoroughly until a homogeneous color is achieved.

Minor adjustments to the base color may be necessary and should be evaluated in the patient's presence.

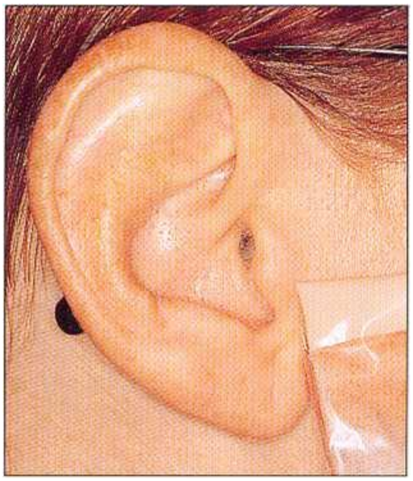


Fig 17-11 Base color is compared to patient's skin with red blush glaze layered over a sample of the base.

Laminar Glazes

Once a base color has been established, one should attempt to identify the other hues that contribute to the skin's complex appearance. Human skin gains its color from the presence of melanin, melanoid, oxyhemoglobin, reduced hemoglobin, and carotene in the epidermis, dermis, and subcutaneous tissue (Edwards and Duntley, 1939). Laminar gla/.es are layers of color painted individually into the mold before packing the base color. The application of laminar glazes is an attempt to mimic the histologic structure of human skin. This process combined with the placement of thread and flock for blood-vessel simulation is intrinsic coloration. Through intrinsic coloration, one can simulate the exact likeness of the patient's skin in color, texture, heterogeneity, and translucency (Fig 17-11). Common colors for laminar glazes include the following:

- Red blush glaze—Simulates the classic pink appearance of skin as evidence of surface vasculature. This glaze should be high in translucency and typically varies in hue from a peach to deep red.
- Golden tan glaze—The tan color observed in skin due to the presence of melanin. This glaze is also high in translucency.
- Dark brown glaze—Simulates freckles and moles. This is often similar in hue to the golden tan glaze though darker in value and more opaque.
- Opaque, yellow-white color—Simulates cartilage. A portion of the base color can be modified by adding yellow and white pigments to produce the cartilage color.
- Dark blue or purple—Applied for shadow areas.
- Opaque, pink to red helix color—Often a portion of the base is modified by adding red.

Glazes are either a portion of the base color modified slightly in hue or mixed independently from clear silicone. We recommend using a fast- set silicone for the laminar glazes to reduce the potential for colors to migrate during processing. If regular-set silicone is used for a glaze, add a thixotropic agent to decrease the viscosity of the silicone to ensure accurate placement in the mold and a more predictable outcome after processing.

Mixing Laminar Glazes

The red blush glaze is applied as a thin first layer in the mold. Emphasis is placed along the helix, antitragus, and the area of the anlihelix that rims the concha. This layer should remain very thin.

Measure 10 mL clear silicone elastomer into a 30-mL clear plastic medication cup. Add a small amount of red pigment and some dark red flock. The addition of yellow will warm the glaze to a peach color; adding blue will cool the glaze to a deeper, darker red. Small amounts of green pigment or flock can assist in desaturating glaze colors. The red blush glaze should be very translucent (7 on a scale front 1 to 10, where 1 is completely opaque and 10 completely translucent).

A golden tan color is often apparent along the helix and in areas of freckling. The manner in which the glaze is painted in the mold should simulate the appearance of the patient's skin. Skin with a creamy texture will require a smooth, even application of the glaze, whereas mottled or spotty skin requires random dispersion of color in a stippling fashion.

Measure 10 mL of clear silicone elastomer. Add small amounts of red, yellow, and blue pigments to mix a golden brown color with a target transluccncy of approximately 6 to 7. Add flesh, gold, or tan flock to modify the hue and add texture. A small amount of green pigment or flock can be added to desaturate the color if necessary.

Freckles and moles vary in arrangement, size, shape, and number. Mimic the dispersion of freckles and moles evident on the contralateral ear. Freckles are typically not symmetric in shape, so creating perfect circles should be avoided. Moles, on the other hand, are often symmetric in shape.

Measure 10 mL of clear silicone elastomer. Add red, blue, yellow, and brown pigments and dark red and purple flock to create a dark brown, saturated color with a transluccncy of approximately 4. The freckle color can be thickened after catalyzing by adding thixotropic agent to prevent migration in the mold.

The appearance of cartilage is apparent along the superior and inferior crura of the antihelix and on the tips of the tragus and antitragus. Mixing the cartilage color is quickly and easily done by modifying a portion of the base.

Measure 5 mL of base color. Add a small amount of white pigment, yellow, and gold flock to create a yellow-white tint of the base color. Since the target opacity for the cartilage color is higher than that of the base color, little clear silicone elastomer should be added.

The concha, triangular fossa, scaphoid fossa, and posterior section of the helix and concha typically exhibit a shadow. The shadow glaze can also be used to suggest depth where accurate anatomical sculpting was limited due to the presence of a retentive substructure or flat anatomy.

Measure 10 ml, of clear silicone elastomer. Add small amounts of red, yellow, blue, and green pigments and dark red, dark blue, and purple flock to produce a dark purple color with low- saturation, and a translucency of approximately 5 (on a scale from 1 to 10).

The helix often exhibits a fairly uniform hue that varies from peach or pink to red and is observed on the superior two thirds of the helix. The helix color can also be easily established by modifying a portion of the base.

Measure 10 mL of base color. To maintain the target translucency, add an additional 5 mL of clear silicone elastomer. Then add red and yellow- pigments until the desired color is reached. Dark red flock can assist in producing a deep red color.

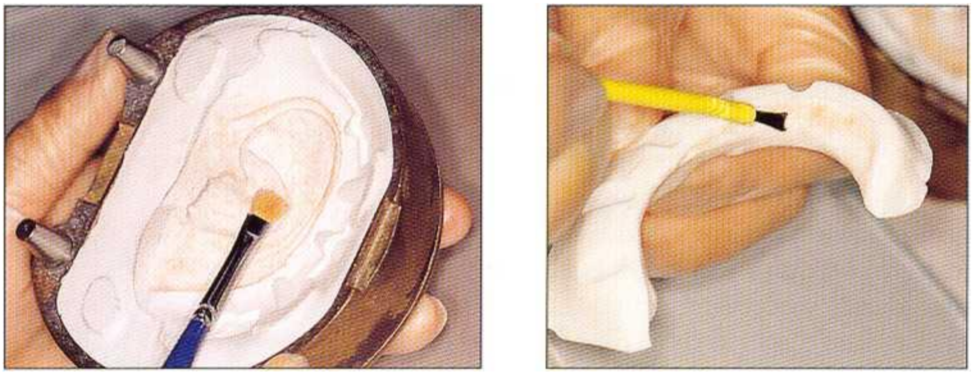
The addition of flock is effective for subtle color changes without affecting translucency. Evaluate the accuracy of glazes by sandwiching the color in a transparent plastic sheet and comparing the glaze to the target skin tone of the patient. Since laminar glazes will be backed by the base color, it is important to evaluate them layered over a sample of the base color (Fig 17-11). Colors that are mixed for laminar painting can also be used for extrinsic coloration. Five mL of each of the glazes may be put aside for this purpose.

Packing the Mold: The Intrinsic Approach

This section describes the method used to paint and place silicone into the mold. A white die stone mold aids in assessing colors as they are painted into the mold. This is a chairside procedure where easy access to the contralateral ear provides reference for accurate placement of color.

Laminar Painting in Mold

The following description assumes that a three- piece mold is used in the fabrication of the auricular prosthesis. The mold consists of the base; the wedge, which extends along the helical undercut;



Figs 17-12a and 12b Red blush glaze is the first layer painted into the mold.

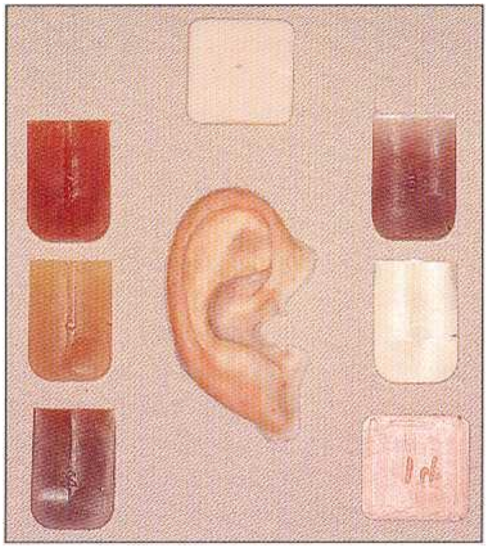


Fig 17-13 Auricular prosthesis before extrinsic coloration with wedge samples of intrinsic glazes. *Clockwise from lower left,* silicone samples represent: freckle color, golden tan glaze, red blush glaze, base color, shadow, cartilage color, and helix color.

and the top of the mold, which is where the majority of laminar painting is concentrated.

1. Catalyze the first glaze (red blush) according to the manufacturer's instructions.
2. Place the silicone onto the glass mixing palette and use a metal spatula to spread it very thinly on the glass to assist in eliminating air bubbles.
3. Using a 7 mm "bright" paint brush (Fig 17- 3), paint a thin layer of the glaze into all areas of the top of the mold that represent the external surface of the prosthesis (Fig 17-12a).
4. Paint a similar layer on the wedge of the mold that represents the posterior surfaces of the helix and concha (Fig 17-12b). The red blush glaze is a very translucent glaze, and if it is painted too thickly, the surface of the finished prosthesis will appear too translucent (Fig 17-8).
5. Collect the remainder of the catalyzed silicone and place in a prepared wedge mold for processing (Fig 17-6). A sample of each color used in the final prosthesis should be kept for the patient's record (Fig 17-13). Once the first layer of silicone is in the mold, simulation of blood vessels and freckles can be added (Fig 17-14).

Surface characterization

Incorporation of surface characterization is important in creating a lifelike result. Look for freckles, moles, broken capillaries, prominent blood vessels, and other skin markings on the contralateral car that can be used to characterize the prosthesis. Freckle simulation can be achieved using the freckle glaze or by placing dry flock directly into the mold. After catalyzing the si 1 i-

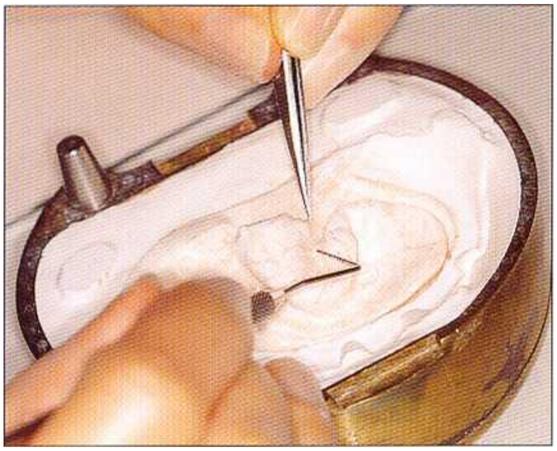


Fig 17-14 Tweezers and periodontal probe used to place thread for blood-vessel simulation.

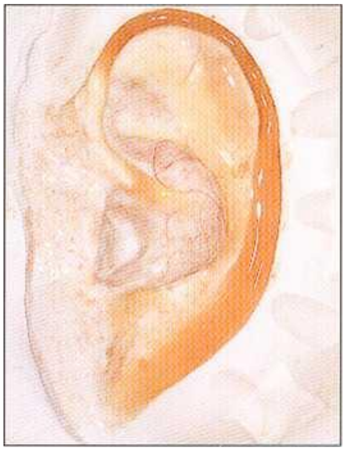


Fig 17-15 Intrinsically painted mold prior to packing the base color.

cone glaze, a thixotropic agent can be added to achieve lower viscosity, which will assist in preventing freckles from running. Using a disposable brush (Benda Brush, Gentrix, Shelton, CT), carefully add tan flock or the catalyzed freckle glaze in clumps to mimic a freckle. A combination of tan and brown flock carefully placed will look like a mole.

Blood vessel simulation can be achieved by using either flock or thread. Place red flock directly in the mold to represent obvious broken surface capillaries. This should be done in moderation since bright red flock on the surface of the finished prosthesis may draw unwanted attention. Red flock is helpful in adding heterogeneity to the midantihelix region where heavily vascularized skin stretched over cartilage often reveals many intricate intersecting capillaries. Simulate larger blood vessels with thread or yarn. Typically this is observed in the concha and the superior antihelix regions. The thickness of the threads determines how distinct the vessels will appear in the final prosthesis. Very fine rayon threads may need to be twisted together to be evident after processing. Use a narrow instrument to secure the thread in the red blush layer of silicone. A periodontal probe and pair of tweezers can be useful for this purpose. It is not necessary that all parts of the thread contact the silicone, for this adds to the three-dimensional quality of the final result (Pig 17-14).

Catalyze the remainder of the glazes one at a time and de-air in the same manner used for the first glaze. Paint the glazes carefully in the mold in areas where the colors arc observed on the contralateral ear (P’ig 17-7). Isopropyl alcohol can be used to remove catalyzed silicone from brushes and the glass palette. Clean brushes immediately after use.

Application Techniques

The following points will assist in accomplishing successful intrinsic laminar painting (Pig 17-15).

- Take care not to disturb a previously applied glaze while painting in subsequent layers of color.
- Random stippling can be effective in adding subtle color differences to break up the surface of a previously applied glaze.
- Due to its opaque nature, cartilage color should be applied conservatively. Keep in mind that the mold represents a three-dimensional negative. Areas of height in the mold actually represent depth in the final product, and conversely, areas of depth in the mold represent prominences in the final cast.
- Taper the edges of pooled color to create a smooth transition where colors blend. This is particularly important where shadow and cartilage colors intersect with other colors in the

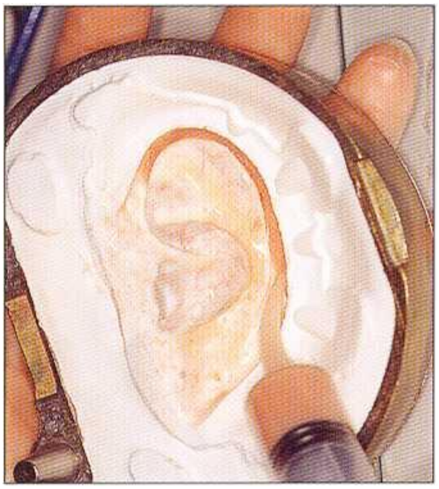


Fig 17-16 Syringe used to inject silicone into helical groove.

mold. Freckles, which should appear fairly distinct on the surface of the prosthesis, should not be tapered.

- The helix color can often be placed in bulk into the superior area of the helical groove. Taper the color toward the inferior portion of the car to achieve a gradual blend into the lobule area. Thin layers of helix color can be placed along the ear lobe where observed on the contralateral ear (Fig 17-16).
- Placing the flask in a 75°C oven for a few minutes between glazes will help to set the color.

Intrinsic laminar painting is best achieved using fast-set silicone. While regular-set silicone may run together if a thickening agent is not added, a fast-set silicone will begin to set more rapidly, increasing the chance that colors will remain where they were originally placed in the mold. If colors migrate during processing, corrections can be made with extrinsic coloration if the migration is not very severe. To control migration, laminar painting should be performed with conservative amounts of silicone to avoid overpacking the mold. If an excessive amount of material is packed in the mold, some colors (ie, the base) may push previously placed colors out of position.

Packing the Base Color

The base color is the last color placed in the mold. Experience allows one to determine exactly how much of the base is needed to fill the mold before closing. Because the base color is placed into the mold in much greater bulk than the laminar glazes, it is essential that the base color be effectively de-aired prior to packing.

Reserve 5 g of uncatalyzed base for use in making any repairs after processing. Catalyze the base according to manufacturer instructions and place the catalyzed base in a plastic container to hold three times the amount of silicone catalyzed. Place under a bell jar attached to a vacuum pump and de-air for 3 to 4 minutes. If fast-set silicone is used for the base, the spatulating technique for de-airing may be more suitable. For the spatulating technique, spread the catalyzed silicone on a large, clean glass palette with a large spatula or palette knife until most of the air bubbles have been forced out of the silicone. Care should be taken to not introduce air into the silicone during the packing procedure.

Cut the tip (approximately 5 mm) off the end of a 12-mL plastic syringe. Using a small metal spatula, fill the syringe with the de-aired catalyzed silicone to approximately three fourths full. Replace the stopper. Use the syringe to inject silicone into the area of the helix (a place where air is commonly trapped) (Fig 17-16). Continue injecting the sili cone in hard-to-reach areas. Using the metal spatula, apply silicone to the wedge piece of the mold (Fig 17-12b), taking care not to disturb the laminar color that was previously applied. Place the wedge piece in position in the top of the mold. Allow air bubbles to rise to the surface and relieve them with a pointed instrument pulling the edges of the bubble outward.

If the auricular prosthesis is implant retained, place the primed acrylic substructure in position on the base of the mold using clean cotton pliers. Using the metal spatula, place catalyzed base around the edges of the substructure without trapping air. The syringe technique works well to place silicone around the substructure. Once a sufficient amount of silicone has been placed in all areas of the mold and air bubbles removed, carefully close the flask. Use both hands to add pressure in closing. Once the flask has been closed, do not open it. Silicone should be oozing from the middle seam of the flask. Remove excess silicone from the edges of the flask by scraping with a metal spatula.

In the laboratory, slowly add pressure to approximately 700 kPa to ensure good closure of the mold. Place the mold in clamps and process according to the manufacturer's instructions. The addition of heat can accelerate the curing process. For heat processing in an air-circulating oven, recommendations are as follows: process 2186 Fast at 71°C for 2 hours; process 2186 Regular at 90°C for 2 hours. If both fast-set and regular-set silicones are used, process at 90°C for 2 hours. After processing, allow the flask to bench cool for 1 hour.

Extrinsic Coloration

Once the silicone ear has been processed and removed from the mold, remove excess flash with scissors. Unwanted silicone can be trimmed using a handpiece or fiber trimming wheels (Scotch-Brite dental onitized wheels, 2 cm, 3M, St Paul, MN). The seam that appears along the helix of most three-piece mold-processed auricular prostheses should be trimmed so that the surface is smooth to touch. A smooth surface along the seam is necessary for effective extrinsic coloration.

With the patient present in adequate lighting conditions, evaluate the accuracy of the intrinsically colored silicone. A prosthesis that is too light in value can be corrected with extrinsic coloration; however, a prosthesis that appears too dark in value is difficult to remedy and most often needs to be reprocessed. For this reason, one should attempt an intrinsic color match that errs on the side of a lighter value rather than a darker value. If the match is good, then minimal extrinsic coloration will be required. Some extrinsic coloring is usually necessary to disguise the appearance of a seam along the helix and to blend the anterior margin to the surrounding tissue.

In a well-ventilated room or under a ventilation hood and wearing vinyl gloves and a mask, clean the surface of the prosthesis with methanol or isopropyl alcohol. Take care not to introduce oils to the surface of the prosthesis that may interfere with the bond of extrinsic-pigmented silicone adhesive to the silicone elastomer. Measure 3 ml, of a moisture-cure silicone (medical adhesive Type A-891, Dow Corning, Midland, MI) in a 30-mL clear plastic medication cup. Trichloroethane can be used to dilute the silicone to achieve a more fluid mixture. The addition of trichloroethane will retard the cure of the moisture-cure silicone, allowing more working time. Add pigment in small amounts until the desired extrinsic glaze is achieved, and apply the glaze to the surface of the prosthesis in a stippling fashion as necessary (Fig 17-17a). Allow to bench cure overnight. Curing time can be accelerated by placing the prosthesis in an air-circulating oven at 90°C or by using a handheld hair dryer on a low-heat setting. (If a hair dryer is used, be sure to keep the hair dryer moving in a circular motion to avoid constant direct heat on the surface of the prosthesis.)

Each extrinsic glaze should be allowed to set before additional glazes are applied. If multiple glazes are required, use of a hair dryer to accelerate cure time can be helpful. Brushes should be cleaned immediately after use by immersion in trichloroethane.

If one elects to use the intrinsic laminar glazes for extrinsic coloration, then the required glazes

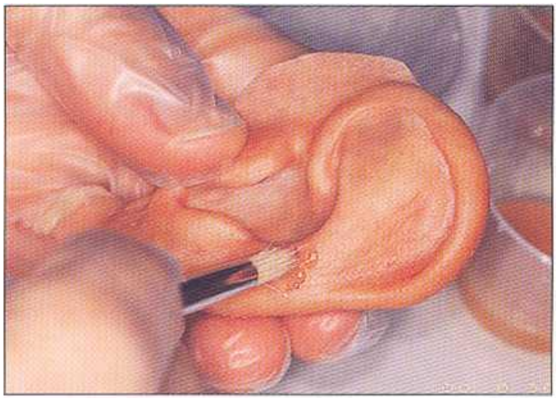


Fig 17-17a Application of extrinsic color.

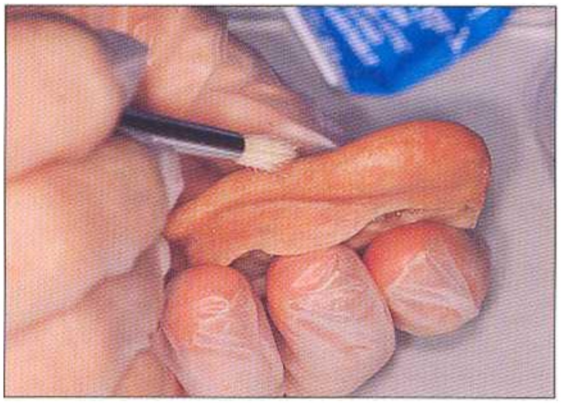


Fig 17-17b Blending the seam.

should be catalyzed according to manufacturer's instructions and applied in a stippling fashion to the oil-free surface of the prosthesis. Isopropyl alcohol or methanol should be used to clean the surface of the prosthesis prior to extrinsic application of silicone. One may find intrinsic laminar glazes too translucent for effective extrinsic coloration and may observe that this technique eliminates much of the sculpted surface texture where extrinsic color is applied.

Blending the Seam Along the Helix

A color similar to that of the helix after intrinsic coloration will help to disguise the seam. With an extrinsic glaze that is reddish in hue and medium in translucencv, apply the glaze to the surface using a stippling technique with a round natural- bristle artist's brush (big 17-17b). After applying the glaze to the surface, place the prosthesis in an air-circulating oven for 10 minutes at 80°C. Repeat this process until a satisfactory match of color is achieved to eliminate the appearance of a seam. If the helix of the patient incorporates many colors, then more than one glaze may be necessary to lessen the evidence of a seam.

The helical glaze used to disguise the seam can also be effective in blending areas of transition of intrinsic colors. A translucent reddish glaze is often all that is needed to provide greater depth of color in the final prosthesis and to enhance areas of blush along the helix, antitragus, and lobule. Evaluate the prosthesis next to the patient's skin after application of each extrinsic glaze and compare to the contralateral ear. View the patient from the front to distinguish differences in value in comparing the existing ear with the prosthetic ear.

Reducing Shine

The application of extrinsic glazes often results in a glossy appearance that may appear unnatural and draw unwanted attention to the prosthesis. Several techniques exist to eliminate the shiny surface that results from extrinsic coloration.

Commercially available cosmetic foam applicators are useful in dulling the surface by altering the surface geometry where extrinsic glazes have been applied. One should apply the extrinsic color, place the prosthesis in the oven for a few minutes, remove, the prosthesis, use the foam applicator to gently blot the surface of the prosthesis where the gloss appears, then place the prosthesis back in the oven. Repeat this process until the glaze has set and the desired matte

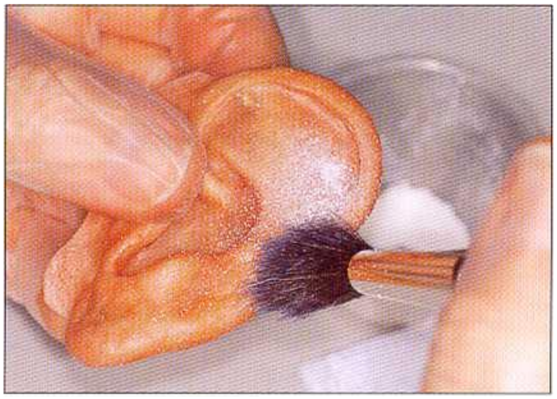


Fig 17-18a Application of kaolin to cured surface of prosthesis.

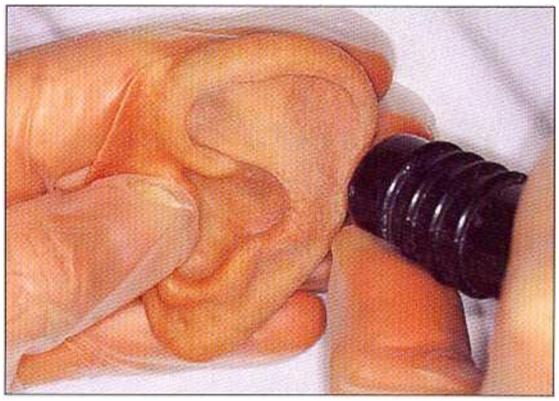


Fig 17-18b Compressed air used to eliminate excess kaolin from surface of prosthesis.

appearance is achieved. This technique can be problematic for two reasons: the foam applicator does remove some of the color, so additional application of glaze may be required, and the technique is time and labor intensive.

Another effective deshining technique through alteration of the surface geometry is described by Erb (1995). One can dull the surface after extrinsic coloration by dusting the surface of the prosthesis with confectioner (icing) sugar. Using a broad natural-bristle artist's brush (Fig 17-3), lightly apply the sugar to the surface of uncured, moisture-cure silicone; allow the silicone to cure; and wash the sugar off with water. The application of the sugar alters the surface geometry of the silicone, effectively decreasing shine after curing. Fine-grade silica fibers (Cab-O-Sil, Factor II, Lakeside, AZ) can also be used in lieu of icing sugar for this technique. If silica is used, a whitish residue is left on the surface of the prosthesis after the moisture-cure silicone has set and the excess silica removed.

Silica fibers can also be used in combination with silicone elastomer to reduce shine. Silica fibers arc mixed with silicone elastomer in a 1:4 ratio, and the mixture is stippled over the glossy portion of the prosthesis. Further alteration of the surface geometry should be performed using a foam cosmetic applicator as the silicone cures. After curing, the application results in a more matte finish.

Application of kaolin powder to the cured surface of the prosthesis is also effective for reducing shine. Ensure that the prosthesis is completely dry and the extrinsic glazes are set by allowing the cxtrinsically colored prosthesis to bench cure overnight. Any tackiness on the surface of the prosthesis from uncured silicone adhesive will present significant challenges with this technique. Dip a soft, natural-bristle artist's brush (Fig 17-3) into a cup of dry Georgia kaolin (approximately 3 mL). Dab the brush onto a clean 4 X 4-inch gauze to disperse the powder among the bristles and to eliminate excess powder on the brush. No excess powder should accumulate on the bristles and the bristles should be splayed to cover greater surface area. Dab the brush over the surface of the clean prosthesis so that the powder clouds the areas of gloss (Fig 17-18a). A compressed-air hose directed at the surface of the prosthesis can be used to eliminate excess powder on the surface (Fig 17-18b). The result should be a matte finish on the silicone. Repeat as necessary. Keep in mind that applying excessive kaolin to the surface may alter the perceived value of the prosthesis overall. Apply only enough kaolin to reduce the shine.

Summary

Though techniques and approaches to color in maxillofacial prosthetics are varied, the techniques described here represent methods that have been in routine clinical use. The extent to which one is successful using the techniques described here depends to some degree on experience and individual ability.

Spectrophotometry and color formulation help to alleviate the documented problem of metamerism while providing an objective means of color assessment. This chapter has described the use of this technology in the context of currently accepted coloring methods as a means of achieving a base color match. This technology does not replace the need for color-matching skills, rather it is a tool for enhancing those skills and applying an element of objectivity to an otherwise subjective task.

Coloring facial prosthcscs is not a skill easily learned. Willingness to learn and understand color theory concepts of hue, value, saturation, franslucency, and pigment loading are necessary if one is to excel in coloration of facial prostheses. A keen eye and attention to detail are paramount in the ability to detect and duplicate skin tones. Finally, the willingness to take time to learn, practice, and improve on techniques is essential for the development of an accomplished colorist.

References

Andres CJ, Haug SP, Munoz CA, Bernal G. Effects of environmental factors on maxillofacial elastomers. Part I: Literature review. J Prosthet Dent 1992;68:327.

Bergstrom K. Materials and artistic conceptions. In: Branemark P-I, Tolrnan DE (eds). Osseointegration in Craniofacial Reconstruction. Chicago: Quintessence, 1998: 207.

Edwards EA, Duntlcy SQ. The pigments and color of living human skin. Am J Anat 1939;65:1.

Erb RA. Intrinsic and extrinsic coloration of prostheses. In: McKinstry RE (ed). Fundamentals of Facial Prosthetics. Arlington, VA: ABI Professional Publications, 1995:161.

Hunter RS, Harold RW. The Measurement of Appearance. New York: John Wiley & Sons, 1987:3.

Kuehni RG. Computer Colorant Formulation. Toronto: DC Health, 1975.

Ma T, Hicken SC, Buchanan CR, DeBoie RG. Chairside color verification for facial prostheses. J Prosthet Dent 1988;60:2 19.

Ma T, Koran A, Johnston WM. The color accuracy of the Kubelka-Munk theory for various colorants in maxillofacial prosthetic material. J Dent Res 1987;66:1438.

Roberts AC. Light and color. In: Facial Prostheses. London: Henry Klimpton, 1971:59.

Troppmann RJ, Wolfaardt JF, Grace M, James AS. Spectrophotometry and formulation for coloring facial prosthetic silicone elastomer: A pilot clinical trial. J Fac Somato Prosthet 1996;2:85.

Fabrication of Custom Ocular Prostheses

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<> Carl J. Andres, DDS, MSD

Patients requiring treatment with custom ocular prostheses are those who have lost ocular structures through orbital evisceration or orbital enucleation. Evisceration is the removal of the contents of the globe, but leaving the sclera and on occasion the cornea in place. Because the extraocular muscles are left intact, good mobility of the prostheses is usually possible. However, with the cornea left in place, sensitivity to a prosthesis can result. Enucleation is the removal of the eyeball itself, usually with the extraocular muscles attached to an orbital implant. The purpose of the implant is to replace lost tissue volume and improve prosthesis mobility. Modern orbital implants are made of metal, silicone, hydroxyapatite, or acrylic resin and usually take the form of a sphere. The mechanism of attachment of the extraocular muscles to the implant can be through a loop or screen on the implant, which allows a location for suture placement, but more often, muscle attachment is in the form of a crossed notch on the anterior surface of the implant into which the extraocular muscles can be placed and sutured together. Because this latter morphology allows the muscles to be sutured to each other and stretch over the implant rather than sutured to the implant itself, there are fewer postsurgical complications. In addition, this morphology creates four projections into the posterior wall of the defect that can engage the posterior surface of the prosthesis, allowing excellent mobility. At the time of surgery, a plastic conformer is placed into the defect. It serves as a surgical stent by maintaining tissues in place during healing and space for the planned ocular prosthesis (Fig 18-1).

Patient Evaluation

The initial consultation and evaluation of a patient prior to fabrication of an ocular prosthesis provides insight into its prognosis. The evaluation should include a physical and psychological appraisal of the patient, including the desires and expectations of the patient related to the proposed prosthesis. Patients should be counseled regarding expected results, with specific emphasis on their role both during the treatment phase and after completion of the prosthesis. The importance of a patient’s understanding of these aspects relative to the success (or failure) of the prosthesis cannot be overemphasized.

The patient will usually present for treatment with either the conformer or an existing prosthesis in place. The prosthesis or conformer should be removed and a thorough examination of the defect performed. The examination should include a determination of adequate healing and lack of irritation from the existing prosthesis or conformer. If healing is not adequate or if there

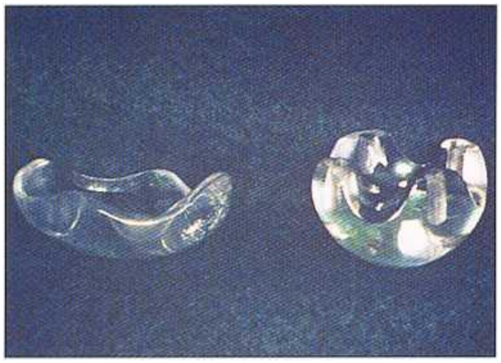


Fig 18-1 The Iowa style of implant with crossed grooves for muscle placement *(right)* with plastic conformer *(left).*

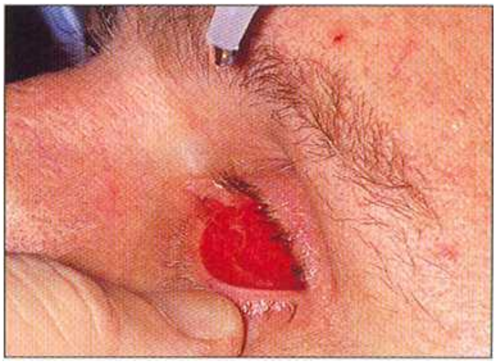


Fig 18-2 Examination of the ocular defect site and application of topical anesthetic prior to impression making.

is a dehiscence over the implant, an ophthalmologic surgeon should be consulted. If there is irritation due to the existing prosthesis or conformer, it should be adjusted and repolished; the patient will need to return when the inflammation has subsided so that the impression can be made.

The initial examination includes observation of the relationships of the palpebral fissure in an open and closed position as well as evaluation of the muscular control of the palpebrae and the internal anatomy of the socket in a resting position and during full excursive movements of the eye musculature, particularly mobility of the posterior wall of the defect during movement of the intact eye. The condition of the conjunctiva should be observed as well as the depth of the fornices and presence of cul de sacs, which can be used to improve motion of the artificial eye. The presence of any abnormalities in the tissue, adhesions, or muscle attachments should be noted.

Impression and Wax Pattern Fabrication

When it has been determined that the patient is ready for treatment, the delect should be anesthetized with 0.5% tetracaine hydrochloride ophthalmic solution topical anesthetic to increase comfort during the impression procedure. One or two drops of the solution should be placed onto the conjunctiva of the defect and allowed to take effect for about 15 minutes (Fig 18-2).

Impression techniques for custom ocular prostheses vary depending upon operator preference and defect morphology. The most common techniques are the molded shell or stock ocular tray technique and the external tray technique. The molded shell technique utilizes a stock ocular impression tray and works well for the vast majority of surgical enucleation and surgical evisceration situations, but it has the potential of the tray creating an overextended impression. The external tray technique is particularly useful for patients with less desirable morphology of the defect, usually as a result of trauma, infections, or complications during healing, as there is no tray placed within the defect. Additionally this technique does not require stocking special materials such as ocular impression trays in the office. However, it is more difficult to capture a bubble- free impression of the defect with this technique.

Stock Tray Impression Technique

An impression is made of the ocular defect using a disposable syringe (20-mL syringes, 1-mL graduations [Curtis Matheson Scientific Laboratory Equipment, Houston, TXJ), stock ocular tray (ocular tray, ophthalmic impression material [American Optical, Southbridge, MA]), and nonirritating impression material, ie, ophthalmic- quality irreversible hydrocolloid.

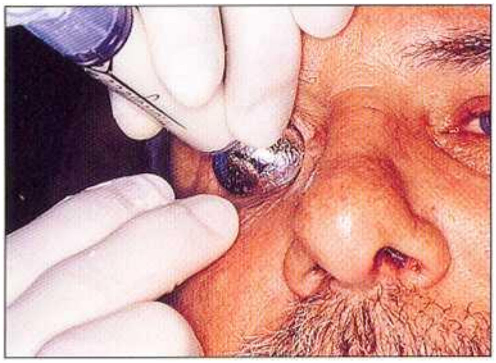


Fig 18-3 Fit of the stock ocular impression tray is checked.

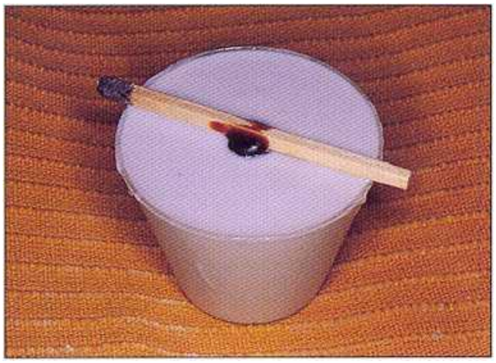


Fig 18-4 Silicone wax pattern mold.

During the procedure, the patient should be seated in an upright position with the head supported by the headrest. This position allows the natural positioning of the palpebrae and surrounding tissue relative to the force of gravity. The stock tray should be placed into the defect before making the impression to determine the proper orientation and fit without overextension (Fig 18-3). The tray-syringe assembly should be oriented so that the stem of the tray is parallel to a line perpendicular to the pupil plane of the natural eye. The tray should be oriented to support the lids in a similar position to the lids of the natural eye. Adherence to tray orientation and lid support is helpful in final adjustment of the wax sclera and orientation of the iris button. The tray is then removed from the defect. Ophthalmic- quality irreversible hydrocolloid is mixed and loaded in the syringe, and sufficient material is ejected to fill the concavity of the tray. The tray is then reinserted and reoriented in the defect; sufficient material is injected to elevate the lid contours similar to the normal side.

After sufficient time has elapsed for proper set of the impression material, the assembly is removed and the impression examined for defects and voids. The impression tray may be removed from the syringe, rinsed with water, and replaced in the defect to check for proper lid contour and mobility of the impression. The patient is instructed to look to the right, left, up, and down without moving the head. If the impression was properly oriented and extended into all available areas, the stem of the tray should follow the movement of the pupil of the natural eye. If the tray and syringe were properly oriented during the impression procedure, the location of the stem on the frontal surface of the scleral pattern becomes a starting point for the orientation of the lens-button assembly.

After an acceptable impression of the eye socket has been obtained, it is reproduced in wax. The stem of the impression tray is attached to an orangewood stick with sticky wax. This assembly is suspended over a small medicine cup, and room-temperature vulcanizing silicone mold material (Silastic E RTV mold-making material, Dow Corning, Midland, MI) is poured into the cup to completely cover the impression. Extra catalyst is added when mixing the silicone material to speed the set so that the mold may be removed from the cup in 10 to 15 minutes (Eig 18-4). An incision is made in the mold with a sharp scalpel extending from the superior aspect along the stem of the impression tray through to the bottom of the mold. The mold may be spread apart, the impression and tray removed, and the mold replaced in the medicine cup. The resulting hole in the mold where the stem of the impression tray protruded is used as a sprue for filling the mold with molten wax.

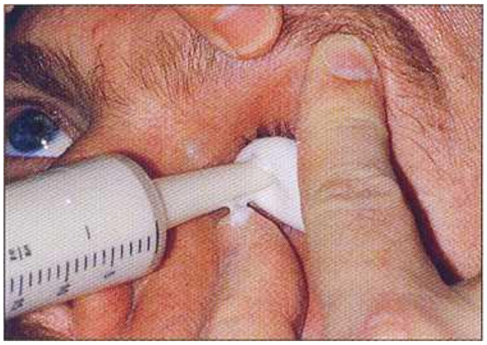


Fig 18-5 Ocular impression is syringed.

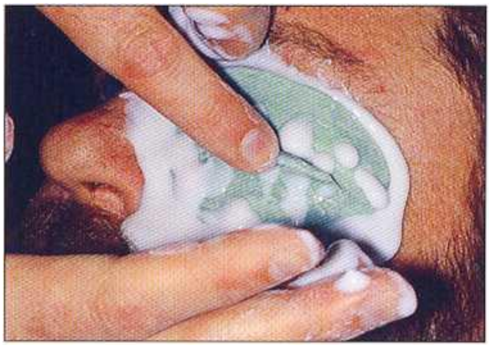


Fig 18-6 External ocular impression tray is in place while the patient maintains a neutral gaze.

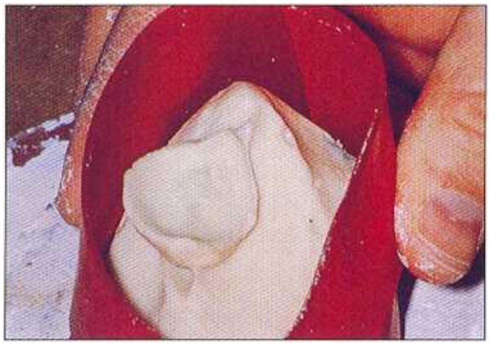


Fig 18-7 Boxing of the impression. The first pour of stone is carried to the height of contour of the defect.

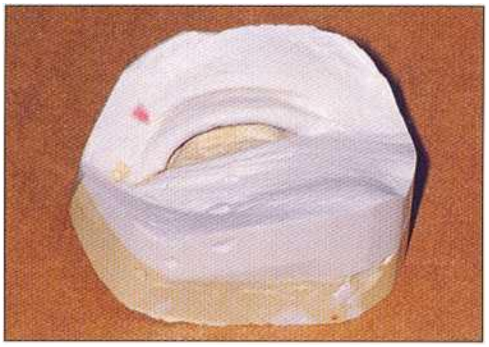


Fig 18-8 Trimmed two-piece cast of the ocular defect.

External Tray Impression Technique

Alginate impression material is mixed and loaded into a disposable 60-mL piston-irrigation syringe (Baxter Healthcare, Deerfield, IL) and expressed into the defect under the lids while the patient gazes directly forward at a fixed point at least 6 feet away. This will allow impressioning of the site with the muscles captured in a neutral gaze position (Fig 18-5). Next a perforated acrylic-resin backing tray is loaded with alginate and placed over the defect, and the material is allowed to set while the patient maintains a neutral gaze (Fig 18-6). This tray can be fabricated from acrylic- resin tray material on a cast made from a facial moulage impression. Since this is only a rigid backing for the impression and one size generally fits all, the tray can be made on most any facial cast available in the office.

Once set, the impression is removed by having the patient wiggle the face to break the seal. The impression is removed from the lower, shallower sulcus first, then rotated out of the deeper, upper sulcus. The impression is boxed and poured in dental stone up to the height of contour of the impression of the defect (Fig 18-7). A separating agent is placed and the remainder of the impression is poured. Once set, the cast can be trimmed on a model trimmer (Fig 18-8).

Next the cast is prepared for wax pattern fabrication by coating the defect tissue surfaces and the mating surfaces with mineral oil. The cast is reassembled and the defect site filled with molten baseplate wax (Fig 18-9). Once the wax has solidified, the cast can be separated and the upper half sectioned to within about one-eighth inch of the medial and lateral canthus with a coping saw (Fig 18 10). The cast can then be fractured and the wax pattern retrieved. The sprue can be removed with a sharp scalpel and the anterior surface of the wax pattern smoothed with a flame (Fig 18-11).

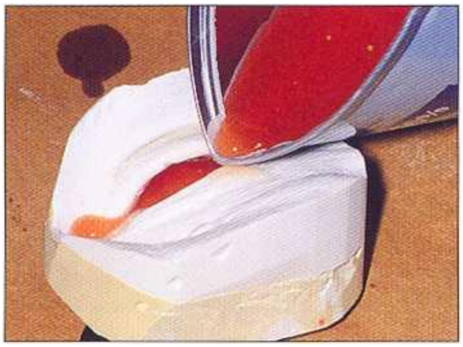


Fig 18-9 After coating both halves of the cast with mineral oil, molten baseplate wax is poured into the cast.

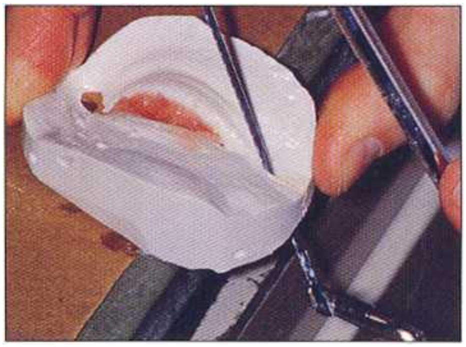


Fig 18-10 Upper half of the cast is sectioned with a coping saw to retrieve the wax pattern.

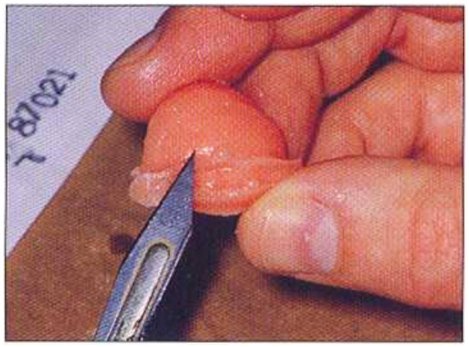


Fig 18-11 Wax sprue and sharp edges are removed with a scalpel blade.

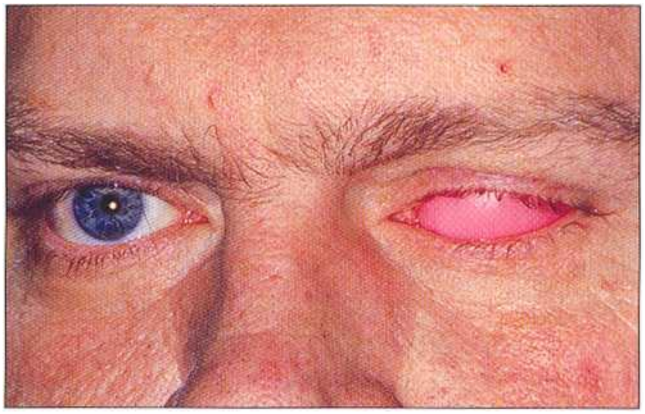


Fig 18-12 Scleral wax pattern in place. Note that additional wax is needed under the superior lid to achieve symmetry of lid opening.

Fitting the Scleral Wax Pattern

The baseplate wax scleral pattern should be highly polished and free from dust, debris, and irritating chemicals before placing it in the ocular defect (Fig 18-12). The fit of the pattern is observed by gently lifting the lids and observing the extension into the fornices. Areas of underextension may be corrected by adding baseplate wax or hard impression wax. The support and contour afforded by the scleral pattern may be compared visually with the patient’s eyes open and by bimanual palpation with the eyes closed. Wax is added or trimmed from the basic scleral pattern until satisfactory contours of the eyelids are achieved, both in open and closed positions.

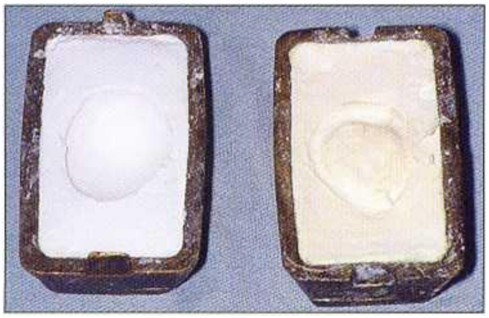


Fig 18-13 Completed mold with space created by the wax pattern.

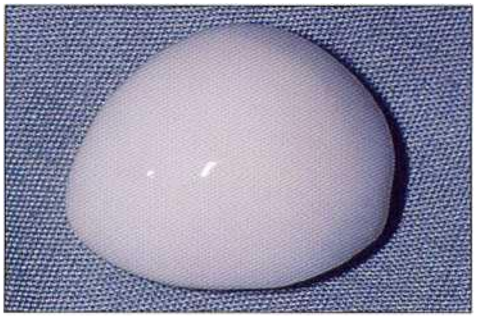


Fig 18-14 Anterior surface of the processed and polished scleral blank.

Custom Ocular Prosthesis Fabrication

The most common techniques for custom ocular prosthesis fabrication are the paper iris disk technique and the black iris disk technique. The paper iris disk technique utilizes readily available materials and techniques familiar to the dental office and allows almost limitless adjustment of coloration. The black iris disk technique requires significantly greater mastery of color matching and painting skills but produces a three-dimensional value to the resulting iris-lens assembly because of a laminating effect in the painting process. Both methods are described here.

Paper Iris Disk Technique

When the wax pattern is determined to be appropriate, it is flasked and processed in scleral resin (Factor II, Lakeside, AZ) (Fig 18-13). The scleral blank is then finished, and it is polished using pumice and acrylic resin polish (Fig 18-14).

The scleral blank is tried in and the middle of the pupil is marked while the patient gazes directly at the clinician. The size of the iris (not including the limbus) is measured using a drafting circle template. The outline of the iris is then marked on the scleral blank using Carmen red ink (Fig 18-15). This ink will transfer to the investing stone, facilitating the appropriate placement of the corneal prominence. The blank is tried in again to verify the location and size of the iris (Fig 18-16). The blank is then reinvested to allow final processing of the prosthesis after coloration. It is important that the iris circle be invested as horizontally as possible to prevent movement of the iris painting during final processing. The location of the iris will transfer to the investment and a Kingsley scraper can then be used to create the corneal prominence of the prosthesis in the investment (Fig 18-17).

A disk of ordinary artist’s watercolor paper is punched out using a die. A selection should include 10 to 12 mm diameters in 0.5-mm increments (available from Ken Specialties, Wood Dale, IT). The size selected should be 1 mm smaller than the measured size of the iris. This will allow the iris to appear to be the appropriate size because the corneal prominence will cause a slight magnification of the iris disk. Using artist’s acrylic paint (Liquitex acrylic artists color, Binney and Smith, Easton, PA), the disk is painted to match the coloration of the natural iris. A good selection of colors for this purpose includes ultramarine blue, burnt sienna, burnt umber, yellow oxide, titanium white, and mars black. It is important to use a thin brush and paint many brush strokes from the center of the disk to the periphery. Colors should be mixed and reapplied in a layering fashion to mimic the colored striations in the patient’s iris. Begin by mixing and painting the background color, which is usually the darkest color and includes the area toward the outer edge of the iris ring. Next the collarette or ring of color around the pupil is painted. The stroma, or area between the collarette and background,

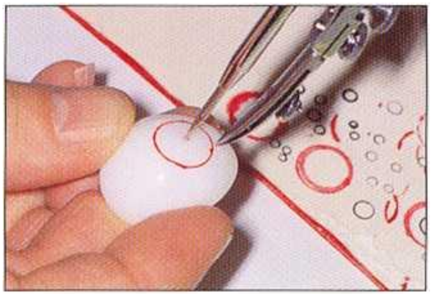


Fig 18-15 Iris is marked on the scleral blank.

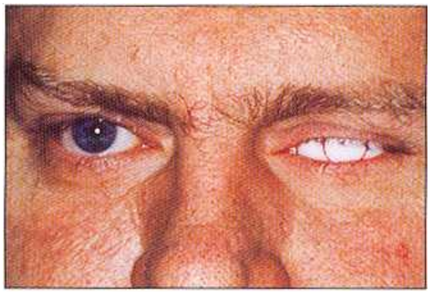


Fig 18-16 Size and location of the iris are verified.

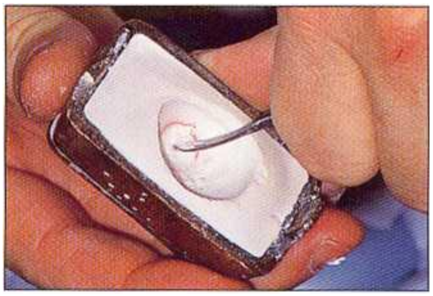


Fig 18-17 A Kingsley scraper is used to create the corneal prominence in the mold space.

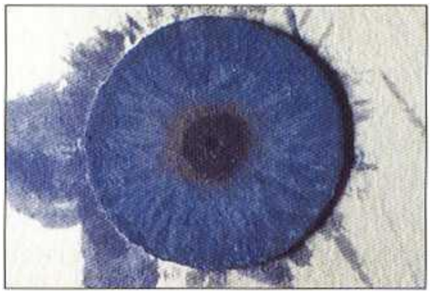


Fig 18-18 Completed iris painting.

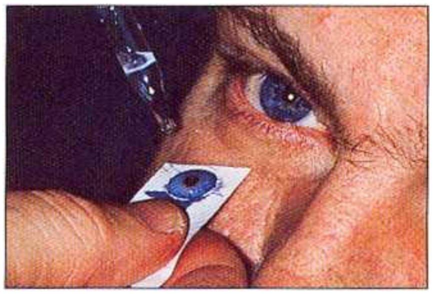


Fig 18-19 Color of the iris painting under a drop of water is compared to the natural eye.

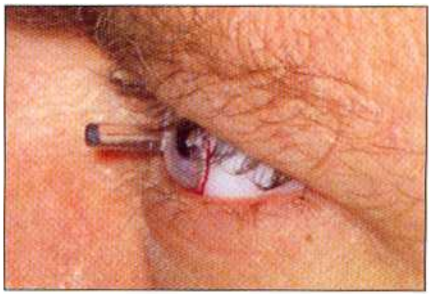


Fig 18-20 Using an ocular blank to survey the appropriate gaze of the prosthesis, the scleral blank is adjusted until the handle of the blank coincides with the view of the normal pupil.

usually the lightest color, is mixed and applied. Finally additional lighter striations are applied to give the painting a three-dimensional effect. A black spot should be painted in the center of the disk to represent the pupil (Fig 18-18). The diameter should mimic the natural pupil under indoor lighting conditions. This will make the size appear relatively appropriate under most conditions. 'Fhe paint can be dried with an ordinary hair dryer, a drop of water applied to create the magnification of the corneal prominence, and the color compared (Fig 18-19). If the coloration requires modification, acrylic paint can be added and rechecked until the desired shade match is obtained. This step can be repeated almost limit- lessly until both the patient and the clinician are satisfied with the coloration.

Using a flat-end bur, a flat surface is prepared in the scleral blank for the iris painting. An ocular button (available from Factor II) is luted to the prepared flat surface with periphery wax and the assembly tried in. The orientation of the surface is adjusted until the sprue points directly at the observer while the patient looks directly into the observer's eye (Fig 18-20). This will ensure that the prosthesis and the natural eve will have the same gaze when viewed by an individual whom die patient is looking direedy at during conversation. Using a large abrasive stone, the entire anterior surface of the scleral blank is reduced at least 1 mm. The central portion around the flat surface is reduced to the edge of the flat surface. The rough surface created by the stone will facilitate painting of the scleral portion of the prosthesis.

The flat portion of the prosthesis is painted the base color of the iris, and a black dot for the pupil is placed. This will compensate for small rears in the paper painting that may occur during processing. Next, the limbus or “fuzzy” demarcation between the iris and sclera is painted. The remainder of the prosthesis is then painted to match the sclera of the natural eye. Fine threads

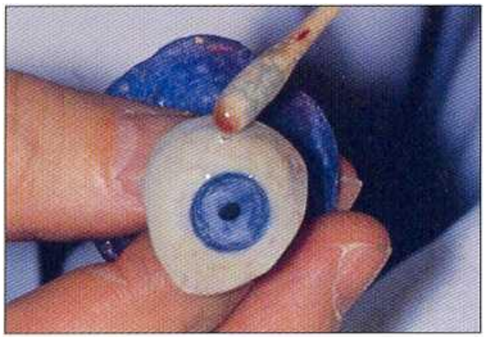


Fig 18-21 Blood-vessel fibers are coated with monomer-polymer syrup to hold them in place for processing.

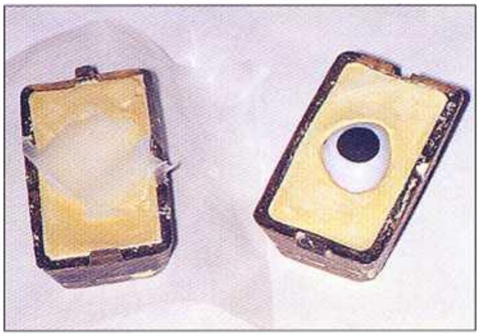


Fig 18-22 Scleral blank with iris painting placed in the flask, clear resin packed, and ready for trial packing.

separated from red embroidery floss are placed on the scleral painting to mimic the blood vessels of the patient's natural eye. It is appropriate to have several shades of embroidery floss available, as the chroma will vary among patients. The entire scleral portion is then coated with monomer- polymer syrup to keep the blood-vessel fibers in place and allowed to set (Fig 18-21).

Once the monomer-polymer syrup has set, the scleral blank is replaced into the flask, and the iris painting is placed on the flat section. Clear ocular acrylic resin (available from Factor II) is mixed and placed into the mold space and the flask trial packed (Fig 18-22). Once trial packed, the flash is removed and the location of the painting verified to ensure that it has not moved during trial packing. The flask can then be closed and the resin processed. Once polymerized, the prosthesis is trimmed and polished using pumice and acrylic resin polish.

Black Iris Disk Technique

The patient should be comfortably seated at a table directly across from the operator and at a matching eye level. The natural eye is observed closely and the diameter of the iris is estimated using a millimeter measurement gauge or optical scale, 'l'lie area of limbus, or the junction of the scleral and corneal conjunctivae, should be included in the measurement. An iris disk approximately 0.5 mm smaller than the actual measurement should be selected, allowing for magnification of the iris by the clear acrylic lens. The iris disk (iris disk, jet or clear, and lens buttons | Ramsdells, Orlando, FL]) normally employed in this procedure is jet black and available in sizes from 11 to 12.5 mm in 0.5-mm increments. The lens buttons are prefabricated in corresponding sizes with various-size jet-black pupil disks incorporated in the center of the flat surface. The technique employed in painting the disk produces a three-dimensional effect. If a greater effect is desired, clear acrylic iris disks are also available in corresponding sizes for painting on both sides as previously described.

Windsor Newton oil pigments (Factor II) arc employed in this technique but are mixed with a monomer-polymer syrup (Factor II) during the painting process. This mixing procedure provides some degree of translucency in the iris painting and permits rapid drying of the pigments.

The iris disk should be painted to match the natural eye in an environment of natural light enhanced by diffuse fluorescent lighting. With the patient seated across the table, the natural eye is again observed closely. The basic eye color or background color is observed along with the limbus color and the color of the collarette. The necessary pigments are placed on a palette along with several drops of the monomer-polymer syrup. Two dappen-dishes are at hand, one containing water, the other containing methylmethacrylate monomer for thinning the syrup.

The background color is applied to the disk first, using brush strokes from the center toward

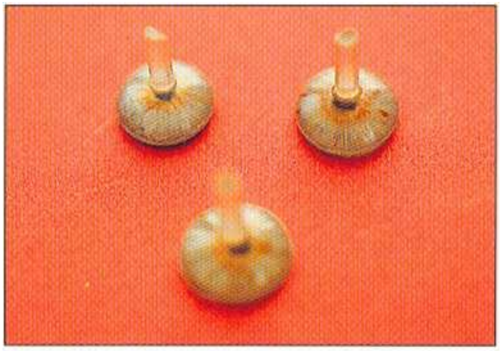


Fig 18-23 Completed iris painting assemblies.

the periphery. The pigment-syrup mixture sets rapidly and much practice is necessary to master the procedure. The mixture may require periodic thinning with monomer. After the background color is applied and dried, a coat of the clear syrup is applied and allowed to dry. Characteristic striations are applied over the clear layer and allowed to dry. A second clear layer is then applied and further characterization accomplished. After the second layer is dried, the limbus color is matched around the periphery of the disk and a third clear layer applied. The color tends to be intensified by the lens button and may be checked periodically by applying a droplet of distilled water to the center of the disk and seating the lens over the disk. The water interface allows the assembly to be viewed as it will appear after the lens and disk are permanently fused. The collarette color is applied over the last clear layer and the final color evaluated with the water interface. After a satisfactory color match has been obtained, a final clear layer is applied and allowed to stand for 15 minutes. The hue should be slightly more intense than that of the natural eye because the color of the iris painting loses value or darkens during processing. A single droplet of the monomer-polymer syrup is then placed in the center of the iris disk and the lens button is gently placed and centered. The excess syrup will harden during the polymerization process. Care must be taken not to apply a great deal of pressure or the iris painting may be distorted. The assembly is allowed to dry for 15 to 30 minutes (Fig 18-23). If greater three-dimensional quality is desired, a clear iris disk may be painted on both sides and sealed between the black disk and the lens using the same monomer-polymer syrup sealant.

The positioning of the iris-lens assembly on the wax scleral pattern is perhaps the most important phase in fabrication of the prosthesis. Facial asymmetry is not uncommon in the overall population; an individual may have eyes of a slightly different color, one eye may appear a different size than the other, and in some individuals the eyelid opening is greater on one side than the other. However, in all individuals with normal eye structure, the apparent gaze of both eyes is fixed on the same object. If one eye is fixed on an object and the other is apparently looking in a different direction, the observer will realize something is amiss. The object then is to fix the lens button to the scleral pattern in a manner such that the apparent gaze of both natural and artificial eyes is on the same object, or parallel to one another and in the same plane. The patient should be seated comfortably in an upright position without the back or head supported. The operator should be positioned directly in front of and at eye level with the patient. The patient is instructed to fix the gaze of the natural eye on an object at least 3 feet in front of and at eye level with the natural eye. The position of the iris-pupil area of the natural eye in relation to the inner canthus and the upper and lower lids is then transferred to the scleral pattern. The pattern is then removed from the socket and a cylindrical portion of wax slightly larger than the lens button and approximately 1 to 2 mm thick is removed from the marked area. The lens button is then attached in the depression on three small cones of soft utility wax. Sharp corners must be smoothed

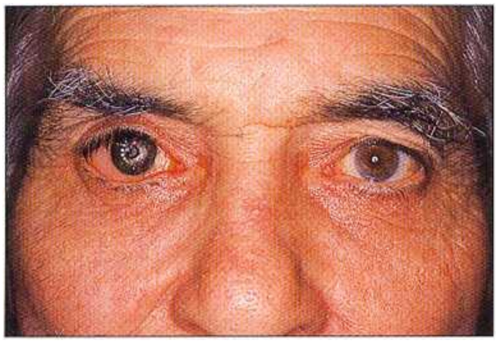


Fig 18-24 Verification of the location of the iris-painting assembly.

with a wax instrument prior to replacement of the pattern in the eye socket. The patient is again instructed to fix his or her gaze on the predetermined object, and the iris-lens assembly is repositioned on the soft wax cones as necessary to achieve the same iris-pupil plane and a line of vision parallel to the natural eye.

The positioning of the iris-lens assembly may be checked by placing a point light source 3 to 6 feet in front of the patient and instructing the patient to fix his or her gaze on the light. The reflection of the light in the natural eye and the artificial eye should be the same when proper alignment is achieved.

The pattern is then carefully removed from the socket without movement of the lens assembly. A hot-wax instrument is used to flow baseplate wax under the lens assembly to prevent further movement. The pattern is then replaced in the socket to recheck the alignment before final waxup (Fig 18-24).

To achieve a simulation of the subtle demarcation between the sclera and iris of the natural eye known as limbus, the final waxing around the lens assembly must be accomplished with great care. The size of the lens assembly selected should be large enough to include the limbus. The lens assembly is placed in a slight depression in the scleral pattern, and a thin layer of wax should be brought up over the curvature of the lens assembly to decrease the size to that of the natural iris not including the limbus area. The thickness of the wax should be uniformly thin, tapering to a fine edge around the periphery of the iris. Care should be taken not to change the shape of the iris from the circular unless a corresponding odd shape is noted in the natural eye. This thin layer of wax will allow the opaque white scleral acrylic resin to flow up over the edge curvature of the lens assembly during the packing procedure, forming a very thin, translucent layer. The color of the painted iris disk will be reflected through the translucent white to provide the subtle, hazy blue violet color of the limbus. A sharp line of demarcation between the iris and sclera is produced if this waxing procedure is not accomplished .

The finished pattern is then invested in a small two-piece brass flask. The bottom half of the flask is filled with improved stone, and the tissue surface of the pattern is painted with stone and placed in the flask to the height of curvature of the edge of the pattern. After a sufficient setting time has elapsed, the stem of the lens assembly is covered with tin foil and the stone is painted with a foil substitute solution. The second half of the flask is poured. After the stone has set, the wax is removed from the mold by boiling, the lens assembly and the mold are cleared of all wax residue, and the mold is painted with foil substitute. Any sharp, thin areas of stone at the edge of the mold should be removed to prevent breakage and incorporation into the prosthesis. The mold is allowed to cool to room temperature before packing with white scleral acrylic (ophthalmic acrylic, scleral powder [American Optical, Southbridge, MA]). The mold is closed and polymerized by boiling for 2 hours. The resulting scleral blank is deflasked, trimmed, and polished.

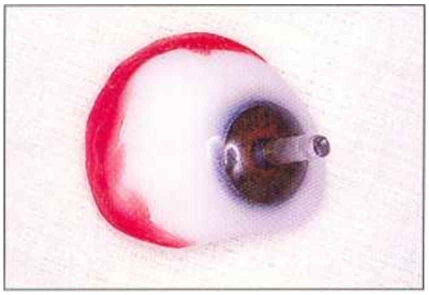


Fig 18-25 Wax is added to the processed scleral blank to improve

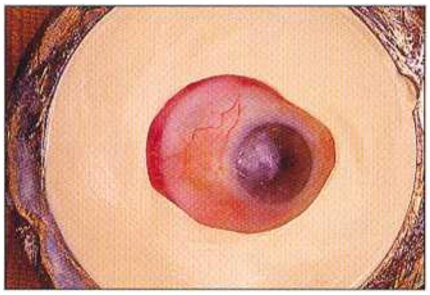


Fig 18-26 Wax is added for processing clear corneal layer.

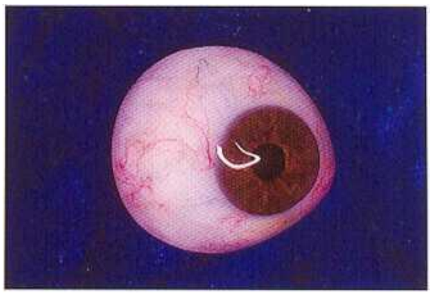


Fig 18-27 Completed custom ocular prosthesis.

The scleral blank is thoroughly cleaned and inspected for irritating projections before replacing in the ocular defect. The position and gaze of the artificial eye is again observed. If any small adjustment is required, wax may be added to the periphery in small amounts to cause repositioning of the iris-pupil plane. Wax may also be added to the front surface of the periphery to improve support of the eyelids (Fig 18-25). If the lids are oversupported, acrylic resin should be removed from the scleral blank. When a satisfactory result has been obtained, the sclera may be tinted to match the natural eye using oil pigments and monomer-polymer syrup. The scleral pattern should not be returned to the defect after application of the syrup because of possible irritation from residual monomer and roughness.

The sclera is slightly roughened using sandpaper disks in preparation for adding the simulated vasculature. Rayon-thread fibrils are placed onto die surface of the sclera using the monomer- polymer syrup. The pattern and type of vessels (sinuous, tortuous, straight, branched) of the opposite eve arc reproduced as faithfully as possible. Several fine filaments together may be separated to provide a branching effect. Tortuous vessels are positioned with a blunt explorer or dull stylus. The modifying oil pigments are mixed with monomer-polymer syrup and applied to the sclera. The area of the caruncle is tinted as required. Care must be taken to cover the rayon thread with clear syrup before applying the pigments or the color of the vessels may be changed. The scleral blank may be returned to the wax holder for comparison with the natural eve.

A thin layer of processed clear acrylic resin must be applied over the surface of the painted sclera to seal in pigment and vascular fibrils as well as to replace any wax adjustments. A sheet of 30-gauge pink casting wax is adapted over the frontal surface of the scleral blank, but not onto the tissue surface or posterior surface (Fig 18- 26). If no positive adjustments have been made around the periphery of the scleral blank, the lower half of the mold previously used may be used again. If significant adjustments have been made, a new mold must be accomplished.

Wax is removed from the mold by boiling, and the mold and scleral pattern are thoroughly cleaned with detergent. Foil substitute is applied to the mold cavity. Some operators advocate use of tin foil burnished over the mold surface to prevent entrapment of stone particles and to ensure clarity of the processed conjunctival layer. If the mold is properly prepared by removal of thin stone margins, the alginate foil substitute provides adequate clarity and separation. The mold is then packed with optical-grade clear methylmethacrylate resin (ophthalmic acrylic, clear powder [American Optical]) and polymerized by slowly bringing to a boil and boiling for 2 hours.

The ocular prosthesis is removed from the mold and carefully trimmed of all flash using sandpaper disks or arbor bands. Flic surface is finely polished using pumice flour. A high-gloss polishing compound is used to achieve the final finish, and the prosthesis is thoroughly scrubbed with soap and water and examined for surface imperfections, preferably under magnification (Fig 18-27).

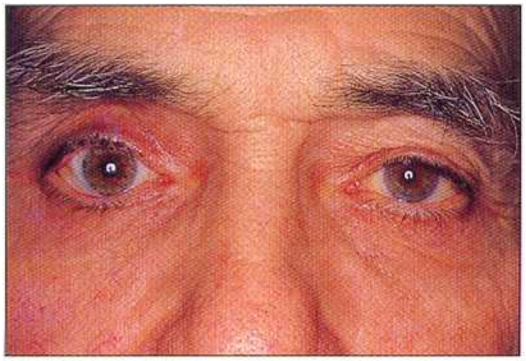


Fig 18-28 Custom ocular prosthesis in place.

Placement of the Custom Ocular Prosthesis

The custom ocular prosthesis can then be placed (Fig 18-28). A feeling of fullness is natural upon placement of the prosthesis. A great deal of subtractive adjustment is contraindicated for the first few days after placement unless obvious irritations are detected. The patient should be instructed on how to remove and place the prosthesis so that the patient feels comfortable maintaining it. The patient should return in 1 day, 3 days, and 1 week for follow-up. There is no need for the patient to remove the prosthesis except for cleaning. Once a week the prosthesis should be removed by the patient and cleaned with mild soap and rinsed well. The prosthesis should be inspected for scratches or deposits. If any are noted, the patient should return to have the prosthesis repolished. The patient should return at about 6-month intervals to have the defect and prosthesis evaluated and adjusted as necessary.

Summary

This chapter has addressed some of the basic principles associated with the treatment of a patient requiring a custom ocular prosthesis. Since many successful techniques are available to the practitioner, only those that are in more common use have been discussed. A properly fitted and acceptable custom ocular prosthesis has the following characteristics:

- Retains the shape of the defect socket.
- Prevents collapse or loss of shape of the lids.
- Provides proper muscular action of the lids.
- Prevents accumulation of fluid in the cavity.
- Maintains palpebral opening similar to the natural eye.
- Mimics the coloration and proportions of the natural eye.
- Has a gaze similar to the natural eye.

Craniofacial Osseointegration Prosthodontic Treatment

o John F. Wolfaardt, BDS, MDent, PhD o
Gordon H. Wilkes, MD, FRCSC o James
D. Anderson, BSc, DDS, MScD

Craniofacial osseointegration allows the head and neck reconstruction team to offer previously unavailable treatment options that provide the patient with meaningful and enhanced quality of life. This chapter will consider craniofacial osseointegration as it relates to reconstruction of the ears, orbits, and midface. This chapter addresses structuring a craniofacial osseointegration team, treatment selection, treatment planning, and prosthesis superstructure construction. It also addresses those phases of craniofacial osseointegration care that must directly involve the prosthodontist. Other technical and esthetic phases of care are dealt with in other chapters.

In 1975 Branemark considered that a skin-penetrating implant may be possible (Albrektsson et al, 1987). In 1977, Branemark and his coworkers installed specifically designed implants in the mastoid region to support a bone-conduction hearing aid (Tjellstrom et al, 1981; Albrektsson et al, 1987). This pioneering work was conducted at Sahlgrenska Hospital in Goteborg, Sweden. In 1979 these same workers placed the first implants in the mastoid region to retain an auricular prosthesis (Tjellstrom, 1990). Since these developments, craniofacial osseointegration has become an accepted part of the armamentarium of head and neck reconstruction.

The Craniofacial Osseointegration Team

Osseointegrated dental implants are well managed within the established dental health care structure. Craniofacial osseointegration provides a greater challenge in this regard as it crosses wider clinical boundaries. Today, there is no one accepted model for providing craniofacial osseointegration care, and internationally several structures have emerged. These structures may not always be patient centered and on occasion may be limited by historical professional politics, lack of knowledge of the appropriate role of disciplines, and misguided professional objectives. Clinicians wishing to become involved in providing craniofacial osseointegration care are well advised to plan the structure of the team with foresight.

A patient-centered model is important for craniofacial osseointegration care, which should occur in an interdisciplinary setting. One approach is that the interdisciplinary team can be considered to function on two levels: the core team and the full team. The core team should consist of a reconstructive surgeon, a prosthodontist, a dental technologist, an anaplastologist,

Table 19-1 The Core Craniofacial Osseointegration Team

Discipline	Responsibilities
Reconstructive Surgeon	Treatment planning Surgery Maintenance phase of care: surgical procedures
Prosthodontist	Treatment planning Assisting at surgery and involvement in intraoperative decisions Biological phases of prosthetic treatment Maintenance phase of care: Supervision of maintenance program Diagnosis and treatment planning Minor surgical procedures Referral to full team members
Dental Technologist ,	Technical phases of prosthetic care
Anaplastologist	Treatment planning Esthetic phases of prosthetic care
Nurse/Dental Assistant	Administer structured patient education Maintenance phase of care: Dressing changes Hygiene procedures Recording of parameters

and a nurse/dental assistant (Table 19-1). To provide optimal craniofacial osseointegration care, the Hill interdisciplinary team will involve a far wider range of clinical skills. An example of a functioning interdisciplinary team is shown in Table 19-2. The individuals in the full team are not involved with every patient but arc called upon when required by the core team. The full team members must have a distinct and identifiable relationship with craniofacial osseointegration care. As an example, radiologists need to have an understanding of treatment objectives of craniofacial osseointegration and the imaging of implants. This means that once the team is structured, each member in the team needs to be trained to develop the knowledge required for the team activity.

As with other aspects of osseointegration, craniofacial osseointegration is protocol driven, and so a structured patient management system becomes essential. To meet this challenge, an ISO 9000 quality system has been developed for patients requiring osseointegration care. This system defines roles within the interdisciplinary team and provides the framework for treatment planning, active treatment, and maintenance of the patient group. Table 19-2 demonstrates that the administrators are designated as Quality Leader and Quality Coordinator. This reflects their role of managing the osseointegration service through a clinical-quality system.

Given the biological knowledge base and clinical skill set of the prosthodontist, she or he is responsible for those issues of prosthetic care that have biological impact. Thus, diagnosis and treatment planning, recording of tissue surfaces as they relate to implants, design of retention, design and assessment of fit of superstructures, and long-term maintenance should be performed by the prosthodontist. The skill sets of the prosthodontist, dental technologist, and anaplastologist should be seen as complementary. The dental technologist provides those skills important to precision superstructure and mold construction. The anaplastologist should be involved in those esthetic phases of patient care requiring art skills to construct the prosthesis, including sculpture and color theory.

Table 19-2 Tho Ful nteraisclpirvary Crcr> ofacici Osscointogration Team

Clinical team

Surg
  Rastic and reconstructive surgeon
OtoJaryr^goVogtsI Maxiiofaoni cx>d oral
surgeon Prc5ttxx*>nt»st Dermatologist
Radiologist
Oral and ma<ik>focial roddogfesl
Hypertxjric medlone pnv^cian
Aucrttfogst
Speech patho*cgist
Denial toohoOogst
Anaolaslotogtst
Psychologist
Social Worker
Gperarng room nurses
Denrai assistants
•VomechorrocH engneer
Elecrroly&s techno^ogst

Administration
Qualrty leader Quoity cocrdnoto Patient scneojler

Treatment Selection

Craniofacial osseoi integration can be of particular benefit tiw reconstruction of selected defects involving die car, orbit, and midfacial delects.

Indications for Craniofacial Osseointegrated Auricular Reconstruction

There arc essentially three treatment options available to patients who arc contemplating treat ment for auricular defects. The first of these is no treatment at all. Patients may reject the prospect of surgery, however minor. They may reject the notion of wearing a prosthesis that is “foreign” and “not parr of me.” Or quite simply, on reflection, they may liud that their auricular defect does not interfere with their daily lives enough to justify- the lime, discomfort, and expense of treatment.

The second and third options arc autogenous (surgical) reconstruction and prosthetic reconstruction. The guidelines for appropriate treat ment selection remain controversial. Autogenous reconstruction of auricular defects has markedly improved due to the pioneering work of many innovative surgeons, but certain auricular defects have limited autogenous reconstructive options, particularly for cancer resections with associated radiotherapy. Regrettably, treatment selection is too often driven by patterns of referral and specialty bias. This may result in inappropriate treatment selection and patients not being in formed in an unbiased manner as to their treatment choices. With appropriate treatment selection and skill, autogenous and osseointegrated

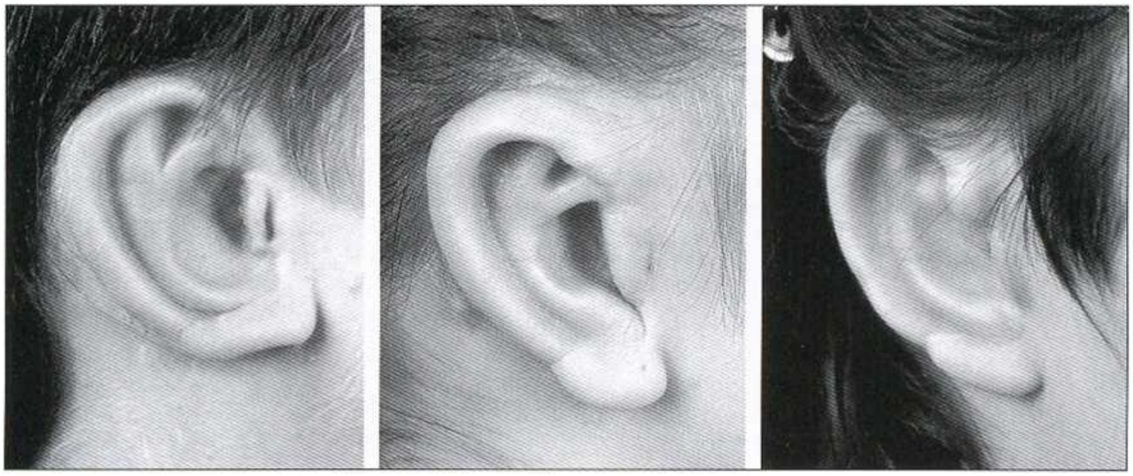


Fig 19-la Autogenous (surgical) auricular reconstructions.

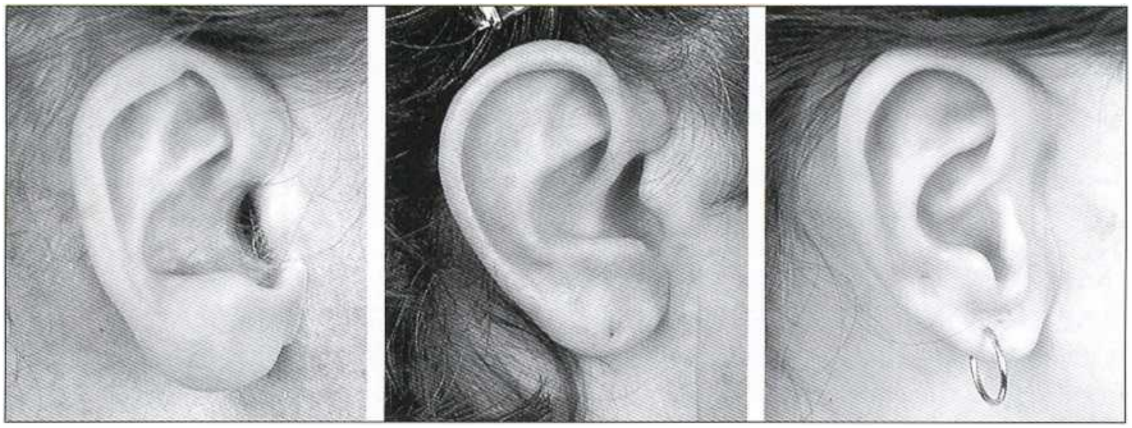


Fig 19-lb Craniofacial osseointegrafion auricular reconstructions.

car reconstruction arc complementary techniques and must be presented in this manner (Fig 19-1) (Wilkes and Wolf'aardt, 1994, 1998). Indications for craniofacial osseointegrated prosthetic auricular reconstruction are listed in Table 19-3.

Availability of autogenous and implant techniques has led to differing approaches in different countries, and the most controversial indication for osseointegrated auricular reconstruction is microtia, particularly in children. The use of osseointegrated implants usually requires removal of ear remnants and produces scarring in the operative field. The consequence of this is that any future autogenous reconstruction options become very limited. If an autogenous ear reconstruction is unsatisfactory for any reason it can be followed by an osseointegrated implant reconstruction, but the reverse is not typically available. For this reason, the use of osseointegrated auricular reconstruction in the microtia patient requires judicious consideration on the part of the clinical team and the patient. This is particularly important for the pediatric age group where a full understanding of the issues is necessary for the patient and family. Consequently, attempting to obtain a satisfactory autogenous reconstruction in classic microtia may be the treatment of choice where surgical expertise is available.

The adhesive retained auricular prostheses must be used with caution as a test for osseointegrated prostheses since adhesive-retained prostheses offer none of the major advantages of

Table 19-3 Indications for Craniofacial Osseointegrated Auricular Reconstruction

Indications
Major cancer resection Radiation therapy Severely compromised local tissue Failed autogenous reconstruction Patient preference Poor operative risk
Relative Indications
Microtia (most controversial) Absence of lower half of ear Calcified costal cartilage

implant-retained prostheses, including ease of placement, predictable retention, improved esthetics, increased life span of the prosthesis, and no ongoing insult to the skin (Wilkes and Wolfaardt, 1998). Adhesive-retained prostheses, however, can be used to help patients judge esthetic impact as an aid in deciding between prosthetic treatment and no treatment at all. They can also be used for patients who want a prosthesis on short notice, or who are suitable for a prosthesis but refuse or delay implant surgery.

Indications for Craniofacial Osseointegrated Orbital Reconstruction

Loss of the contents of the orbit provides a surgical challenge for which there have been few useful options. In the past, reconstruction has usually consisted of closure of the entrance to the orbit with a soft tissue flap. This offered the patient a poor esthetic result and made it difficult for the patient to wear an eye patch to mask the area. In cancer patients, placing a flap over the orbit also impedes tumor surveillance because neither the patient nor the caregiver can carry out examination of the orbit (Fig 19-2). Craniofacial osseointegration offers distinct advantages over autogenous reconstruction in these situations and the esthetic results are far superior (Table 19-4). Given the limitations of available natural retention and the mobility of surrounding tissue usually seen with changes in facial expression, osseointegrated retention is the preferred method of securing these prostheses.

Indications for Craniofacial Osseointegrated Midfacial Reconstruction

Defects of the midface may involve only the nose or may extend beyond the nasal region. The indications for nasal reconstruction are listed in Table 19-5. As autogenous nasal reconstruction may require multistaged procedures, multiple donor sites, and yields greater variability in the ultimate result, patients will frequently prefer a nasal prosthesis. The use of implants for retention involves less surgery, less morbidity, and no need for other donor sites. Again, following a diagnosis of malignancy, an added advantage is the ability- to readily examine the operative site for early detection of tumor recurrence.

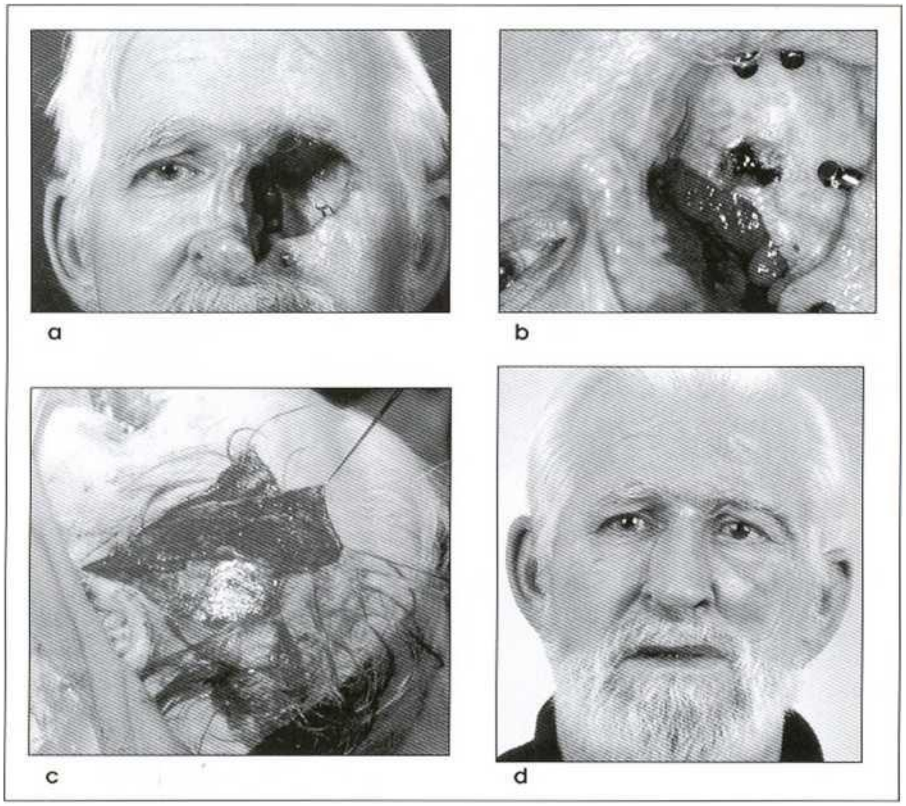


Fig 19-2a Patient with resection of the orbit and midface due to an extensive basal cell carcinoma.

Fig 19-2b Recurrent disease diagnosed by the patient through self examination.

Fig 19-2c Resection of the recurrent disease and reconstruction with a temporalis flap,

Fig 19-2d The patient was able to resume wearing the prosthesis 12 days later.

Table 19-4 Indications for Craniofacial Osseointegrated Orbital Reconstruction

Loss of globe and orbital contents
Severe enophthalmos with/without compromised vision
Unsatisfactory ocular prosthesis with significant eyelid distortion secondary to trauma or radiation therapy where surgical correction has not been successful Poor operative risk

Table 19-5 Indications for Craniofacial Osseointegrated Nasal Reconstruction

Failed autogenous reconstruction Scarring at autogenous donor sites
Following removal of adequate reconstruction due to tumor recurrence Patient preference
Medical contraindication to extensive autogenous reconstruction

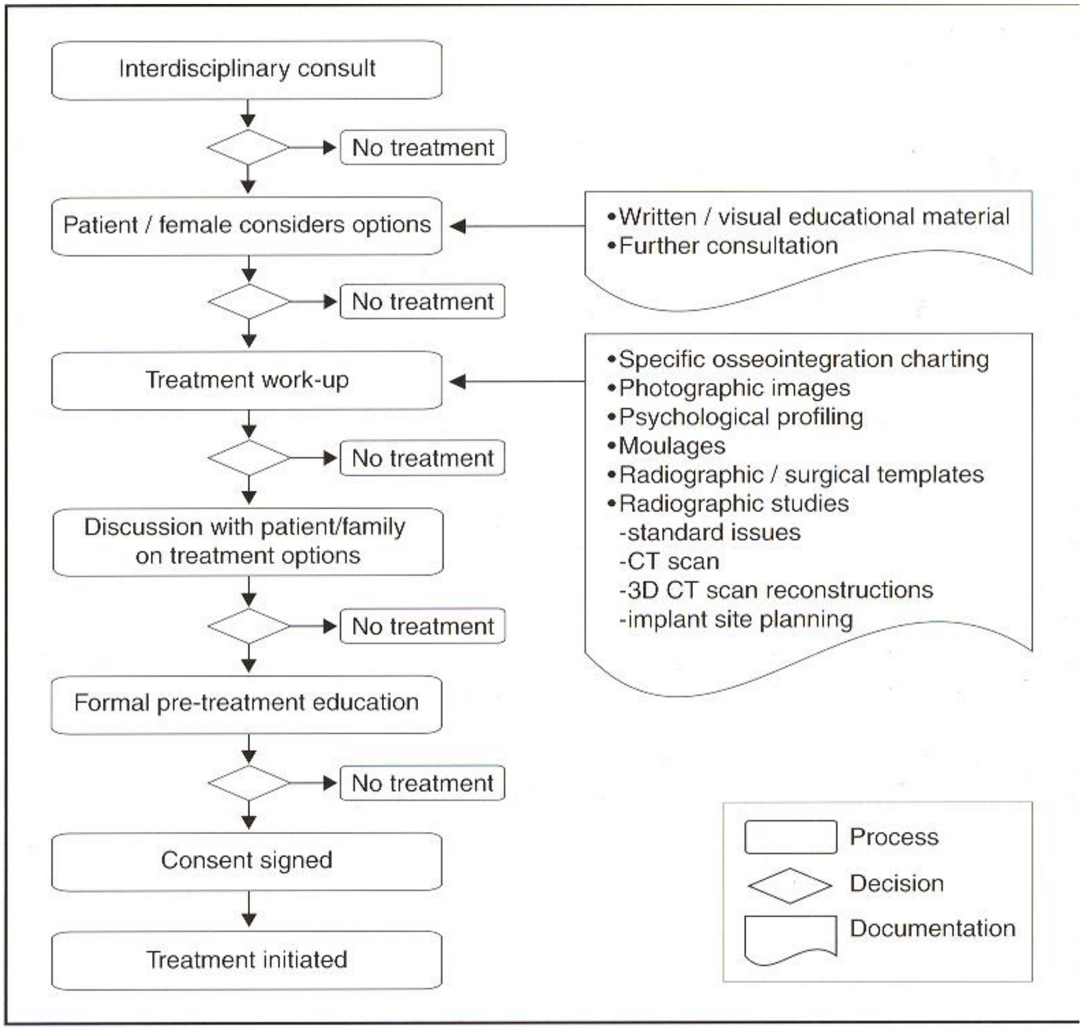


Fig 19-3 Treatment planning process for craniofacial osseointegration.

Treatment Planning

Craniofacial osseointegration care is a stepwise, protocol-driven process involving multiple disciplines. This process can seem complex and at times confusing to both staff and patients. Consequently, it is important that the osseointegration care process be structured and well managed for the sake of all. This applies particularly to the treatment planning process.

The interdisciplinary consultation is the starting point for the process of treatment (Fig 19-3). At the first consultation, the objectives of treatment and general options available arc discussed and appropriate written and visual material is supplied to the patient. A decision to treat should not be made at the initial consultation, but rather the patient is asked to consider their treatment needs to be confirmed at a subsequent visit. Team members then formulate an approach to the individual patient's needs. During this period there may be need for further discussion of the treatment process or potential treatment outcomes.

During the process of pretreatment workup, the following should be completed as appropriate:

- Standardized charting for the specific osseointegration procedure
- Standardized preoperative photographic images
- Pretreatment moulages
- Psychological profiling: general mental health and patient evaluation of existing prosthesis
- Implant positions planned and marked on the skin surface. A moulage of the site is recorded,

and in the case of ears, a moulage is recorded of the nontreatment side. Alternatively, the prosthesis is modeled (digitally or manually) and a planning template of the prosthesis is constructed in clear resin. This is referred to as a *localizing template* and is used as the radiographic, surgical, and prosthetic planning templates. Additionally in ear reconstruction, another template may be constructed by laser scanning the cast. This is referred to as a *detailed anatomical template*. The methods of constructing and using the templates is described elsewhere (Wolfaardt, Troppmann, et al, 1996).

- Where indicated, radiologic examination using CT scanning with a radiographic planning template
- In ear reconstruction, where indicated, audiologic examination is carried out

l'he preoperative assessment allows evaluation of bony sites for implant placement, the risk posed by surrounding vital structures, and bone density as well as the quality and depth of the overlying soft tissues. Systemic or local factors that could obviously influence bone remodeling capacity need to be considered in risk management. Age alone is not considered a contraindication. The patient should have no psychiatric or substance abuse problems, and smoking is a relative contraindication, as are radiotherapy and chemotherapy. While the use of hyperbaric oxygen therapy in the irradiated mandible remains controversial, a past history of radiation therapy in the maxilla, zygoma, frontal, and nasal bones requires assessment for hyperbaric oxygen therapy pre- and postimplant placement to optimize individual implant success. The patient must have a certain level of cognitive, visual, and dexterous ability to maintain osseointegrated implants. Geographic accessibility to an osseointegration service, not only for treatment but also for longterm maintenance, is an important consideration for a patient embarking on craniofacial osseointegration care.

Radiographic Imaging

Planning with standard radiographic views is of limited value in craniofacial osseointegration treatment. Standard posterior-anterior head views with template housing markers may be of use for the orbit to determine the lateral extension of the frontal sinus. Likewise, planning templates constructed from sculpted models of the planned prosthesis are of little value if they are not part of a radiographic plan that relates the overlying prosthesis to the underlying osseous structures. With increasing frequency, computed tomography (CT scanning) in conjunction with an implant-planning software application is a desirable planning tool for craniofacial osseointegration. This approach to planning may not be required for every patient but is extremely helpful where more challenging situations are encountered (Table 19-6).

Where the availability of implant sites is in doubt, a moulage of the treatment site can be recorded and a diagnostic cast constructed. The diagnostic cast can be used to construct templates that are used in the CT scan studies to determine bone availability at the desired sites of implant installation. The templates are constructed in clear resin and have radiopaque markers installed to allow navigation on the images. The images recorded with the planning templates by the implant treatment-planning software allow simulation of the surgery so that the clinically determined implant positions can be related to the availability of underlying bone. The application we use is the SIM/Plant system (Columbia Scientific, Columbia, MD). A CT image is recorded according to a specific protocol, and the image is reformatted through the ImageMaster application (Columbia Scientific). The reformatted image is then loaded into the SIM/Plant system where the implant surgery can be simulated. This allows for identification of desired sites of implant placement; presence of vital structures; implant sizes, positions, and angulations; available bone volumes; general bone densities and bone densities around the implant; and other parameters. The use of this technology in craniofacial implant treatment planning has proven extremely valuable (Fig 19-4).

Table 19-6 Indications for Radiographic Planning Using CT Scanning in Conjunction with Implant Planning Software

Under 10 years of age
Severe trauma
Major resections
Altered morphology
Syndromic patients
History of problems with implant installation

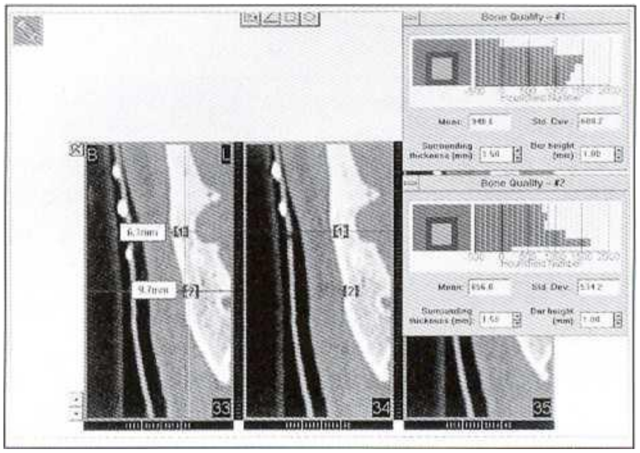


Fig 19-4 Implant-planning software images of mastoid region for an auricular prosthesis.

Once it is determined that the patient is suitable for craniofacial implant-retained prosthetic service, a pretreatment education visit should be scheduled for the patient. At this visit, a structured approach is used to educate the patient on the full extent of their proposed treatment. Once the patient decides to proceed with treatment, the patient signs a consent form that is specific to craniofacial osseointegration.

Auricular Prosthesis Construction

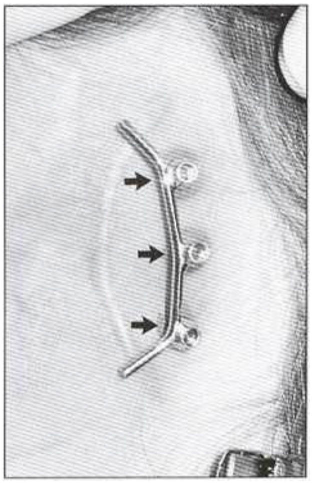
The stages of prosthesis construction described in this chapter relate to selection of the retention system, construction of the resin substructure, and mold construction. Other stages of prosthesis construction are dealt with elsewhere in this book.

In auricular prosthesis construction, it is desirable to construct the superstructure and then record the surface of the soft tissues. The technique developed allows for recording the position of the abutments for superstructure construction. When the fit of the superstructure is accepted the soft tissue impression is recorded in relation to the superstructure.

Retention Selection

Current understanding of the biomechanical performance of craniofacial implants is rudimentary at best. Consequently, a conservative approach to prosthesis and retention design should be exercised until more definitive information exists on the biomechanical behavior of craniofacial osseointegrated implants.

It has been shown in clinical and biomechanical studies that two implants are sufficient to retain an auricular prosthesis (Dc Valle et al, 1995; Wolfaardt et al, 1998). Magnet or bar-and-clip retention are the two primary forms of retention used in the auricular region. While magnet per-



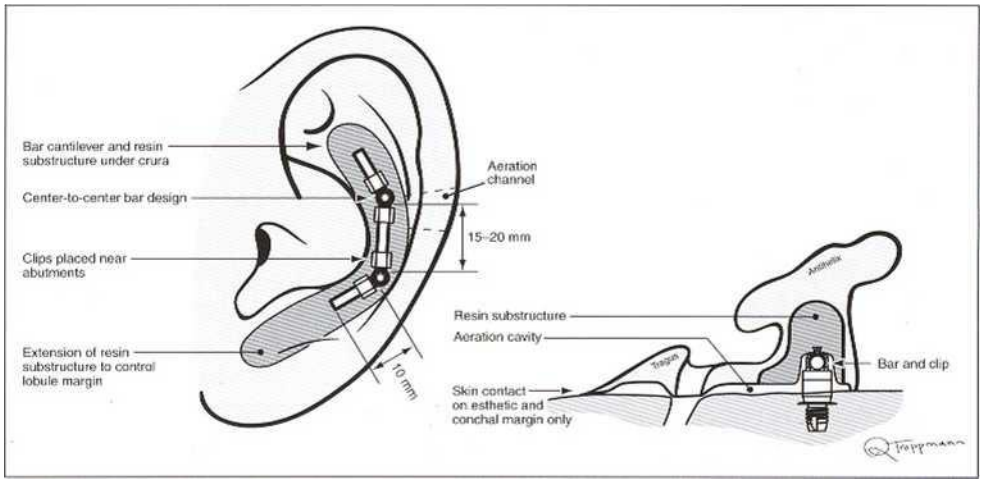

Bar cantilever and resin substructure under crura
Center-to-center bar design
Clips placed near abutments
Extension of resin substructure to control lobule margin
Aeration channel
15–20 mm
10 mm
Antihelix
Resin substructure
Aeration cavity
Tragus
Bar and clip
Skin contact on esthetic and conchal margin only
Troppmann

Fig 19-5 Bar with an eccentric Fig 19-6 Design of the bar superstructure and acrylic resin substructure for an auricular prosthesis, design showing the hygiene shadows on the anterior surfaces of the abutments.

formance has been greatly improved, clinical experience suggests that magnet retention should be used where low dislodging forces are anticipated, where the patient has poor dexterity, or where a special need for independent abutments exists. Typical examples are elderly patients with sedentary lifestyles and patients with arthritis or motor control disorders. Otherwise, the bar-and- clip retention system remains the retention design of choice.

Early bar designs were of an eccentric type so that the bar passed at a tangent to the surface of the gold cylinder (Fig 19-5). This caused the implants to be subject to moment loads. The eccentric design also produced hygiene shadows below the bar. These hygiene shadows were typically in front of the bar and missed by the patient during hygiene routines.

The distance between the implants should normally be 15 to 20 mm. The bar design should be of a center-to-cen ter type (Fig 19-6), and where possible the bar should be within the contours of the prosthesis. The cantilever sections should extend approximately 10 mm. With proper planning and availability of bone, the center section should pass under the antihelix. The upper cantilever should underlie the crura and the lower cantilever should pass below the antitragus. The 10-mm cantilevers arc used for convenience in handling the bar, but the clips should be placed as close to the abutments as possible to avoid excessive loads on the implants. Clip spacers are not used and the clips are allowed to fully engage the bar so that retention is secure but passive. An attempt should be made to maximize the nonlinearity of the bar sections. This is done to reduce the tendency of the prosthesis to rotate around the bar with tissue movement due to changes in facial expression or mandibular movement.

Bar and Substructure Construction

The technique of bar and acrylic-resin substructure construction described on the following page has been developed to minimize moment loads on the implants, control hygiene, and provide efficient construction of replicate resin substructures and prostheses without removing the bar from the patient (Wolfaardt, Coss, and Levesque, 1996).

Bar construction

1. Localizing and detailed anatomical templates are used to determine the preferred position of the auricular prosthesis and the design of the bar (Fig 19-7). The design of the bar is marked on the skin.
2. The fitting surface of components (impression coping, DCA 040, Entific Medical Systems, Goteborg, Sweden; stainless steel abutment replica, DCB 175-0, Entific Medical Systems; and gold cylinder, DCA 072/073, Entific Medical Systems) to be used are checked under a microscope for defects on the fitting surface of the components.
3. The abutment screws are checked and torqued to 20 Ncm with a torque controller (DEA 020, Nobel Biocarc, Goteborg, Sweden). The impression copings arc connected to the abutments and the guide pins are torqued to 10 Ncm. A scaffolding is formed between the impression copings with dental floss. The scaffolding is covered with pattern acrylic resin (Duralay, Reliance, Worth, IE) to link the abutments (Fig 19-8).
4. The skin surface is very sparingly lubricated with a low-potency topical steroid. This allows easier release of the impression and minimizes skin irritation. Low-viscosity polyether impression material (Permadvne L, ESPE, Norristown, PA) is loaded into an impression syringe and the area around the abutments is syringed. Regular-viscosity polyether impression material (Impregum, ESPE) is then syringed over the remainder of the area of interest. The surface of the Impregum is syringed to form retentive loops for the acrylic-resin backing (Flexacryl Hard, Lang, Chicago, IL). Prior to adding the Flexacryl resin, the guide pins are lubricated with petroleum jelly. The Flexacryl is added to cover the exposed surface of the Impregum impression.
5. The impression is recovered and the stainless steel abutment replicas arc connected to the impression copings with the guide pins torqued to 10 Ncm. The impression is boxed and poured in die stone.
6. The cast is removed and the skin surface markings are identified on the cast. These markings are redrawn on the cast surface.
7. Gold cylinders (DCA 072/073, Entitle Medical Systems) are connected to abutment replicas on the cast with gold screws (DCA 074/075, Entific Medical Systems) and torqued to 10 Ncm.
8. Gold bar (#05202555, 1.88-mm diameter, Cendres Metaux, Bienne, Switzerland) is cut to size and the sections are positioned appropriately using small amounts of catalyzed silicone putty (Fig 19-9). A cyanoacrylate adhesive is used to fix the sections of gold bar to the gold cylinders (Zapit, Dental Ventures, Corona, CA). Minimal amounts of the adhesive should be used to keep the size of the solder joints to a minimum.
9. The bar is removed and invested in soldering investment (Dcguvcst L, Dcgussa, Hanau, Germany). Channels directed at the joints are cut before the investment sets fully. The channels allow the flame to be directed at the joint during the soldering procedure (Fig 19-10).
10. The invested bar is preheated in an oven to 500°C for 1 hour. The joints are then soldered with Anoxan flux (Degussa, Frankfurt, Germany) and Degunorm 700 solder (Degussa, Frankfurt, Germany). After soldering, the assembly is freed from the investment.
11. Protector caps (DCB 092, Nobel Biocare) are connected to the gold cylinders prior to trimming and polishing the bar under the microscope. The solder joints must be trimmed and polished to have minimum volume and very little, if any, solder material beyond the joint space.
12. The bar is placed back on the cast and checked for accuracy of fit with a one-screw test (Fig 19-11). The bar is then connected to the patient and checked for an accuracy of fit with a one-screw test.

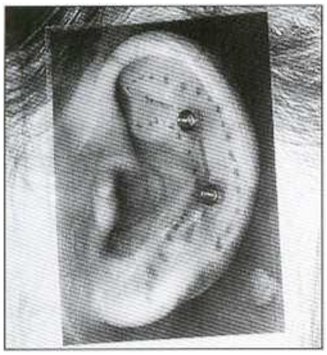


Fig 19-7 Planning templates are used to determine the design of the bar.

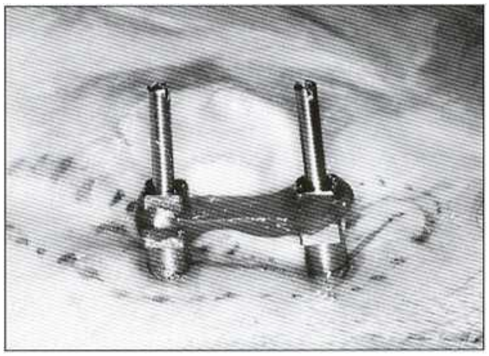


Fig 19-8 Scaffolding of dental floss coated with pattern acrylic resin to link the abutments together.

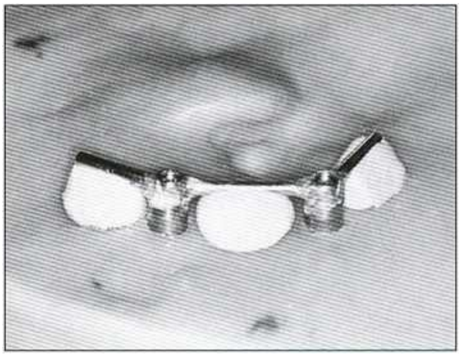


Fig 19-9 Positioning of the sections of gold bar on the cast. The sections of gold bar are held in place with small amounts of silicone putty.

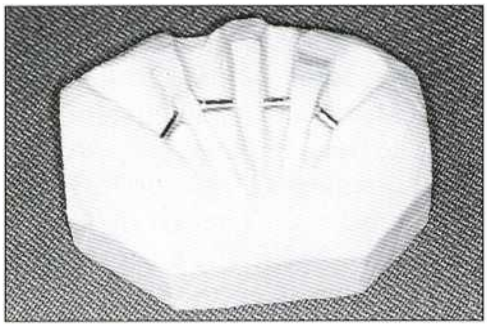


Fig 19-10 View of the channels directed toward the joint for soldering. The channels direct the flame toward the joint.

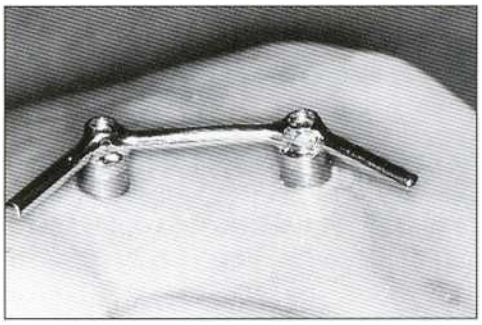
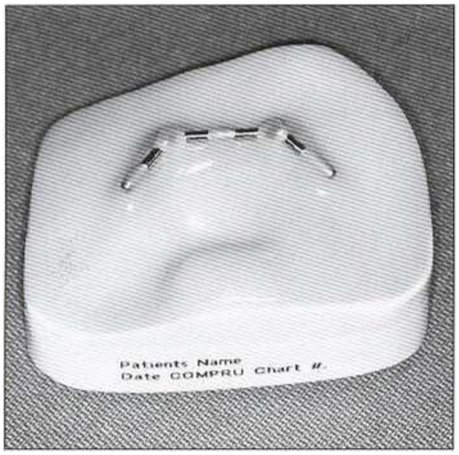


Fig 19-11 View of the completed gold bar. Note the center-to-center construction and the minimal amount of solder material at the joints.

Acrylic resin substructures and protector cap construction

1. After the bar is removed from the cast, one layer of baseplate wax is adapted to the surface of the cast and the wax around the abutments is trimmed. The bar is reconnected and blocked out with block-out wax (Nr. 40032, Bego, Bremen, Germany). A six-degree heated taper tool on the surveyor is useful for this step to contour the block-out wax. Also, slightly wax the surface of the bar, the gold cylinders, and the screw holes. The terminal ends of the superior surface of the cantilever arms should be left exposed (2 to 3mm) so that the resin substructure has a stop to rest on the bar. These stops are important for stability during recording of the skin surface impression. Prior to completion of the prosthesis these areas of contact with the bar are relieved.
2. The next step is to position the clips. The clips need to be parallel and a surveyor is useful to align the clips. The clips (DCB 078, Entific Medical Systems) should be placed as close to the gold cylinders as possible. Remove the clips and ensure that neat channels are left in the wax blockout (Fig 19-12).
3. The blocked-out bar on the cast is duplicated in silicone duplicating material (Wirosil, Bego).
4. After the bar and cast are recovered from the silicone duplicating material, die stone is poured into the silicone mold. The constructed cast is a replica of the blocked-out bar with the channels for clip placement.



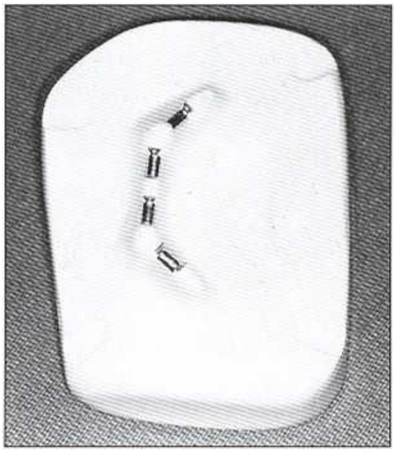


Fig 19-12 Bar in position on the cast with **Fig 19-13** Replicate cast with clips in blockout complete. Note the channels left position and the indexed overcast, in the wax for positioning the clips.

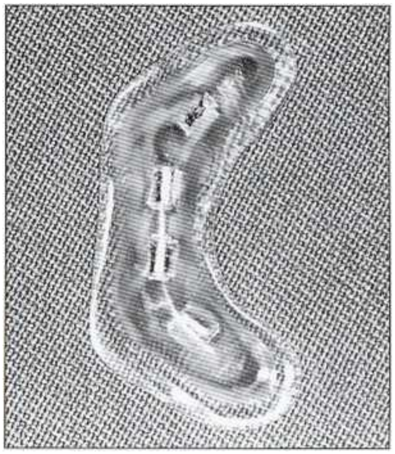


Fig 19-14 Completed acrylic resin substructure.

5. The clips are installed on the bar of the replicated cast in the channels (Fig 19-13). The clips are sealed to the cast with wax. Wax is used to cover the sides of the clips so that there is a space along their sides to allow for insertion of instruments for clip adjustment. Smooth the surface of the wax and coat with a thin layer of petroleum jelly.
6. The bar and clips are covered with a double layer of baseplate wax. Shape the wax to the form of the acrylic substructure design required for the auricular prosthesis. Make reference indices on the cast and separate with a light film of petroleum jelly on the waxup of the acrylic substructure and cast surface. In dental stone, pour an overcast over the waxup. Lightly warm the overcast to soften the waxup but without disturbing the wax blockout or clips and carefully recover the overcast and waxup. After recovering the overcast, apply a separating agent to the surface of the overcast and cast.
7. Autopolymcrizing acrylic resin (Splint Resin, Great Lakes, Tonawanda, NY) is placed into the overcast, small amounts of resin are placed onto the clip wings, and the overcast and replicate cast arc closed. The acrylic resin is cured in a pressure pot.
8. The acrylic-resin substructures are recovered and finished to a high shine (Fig 19-14).
9. Stages 5 to 8 are repeated to construct a second acrvlic-resin substructure if a duplicate prosthesis is to be constructed tor the patient. Likewise, stages 5 to 8 arc repeated to construct a protector cap. The protector cap is worn by the patient while sleeping or at any time the ear should be removed. By altering the design of the acrylic resin substructure to have a far wider contour, the protector cap allows the bar to be protected and prevents it from snagging bedding or clothing. It has been found useful to cover the surface of the protector cap with a heat-cured resilient silicone denture, liner. This has the effect of reducing noise from the protector cap rubbing on the pillow at night, lessening the chance of waking the patient.

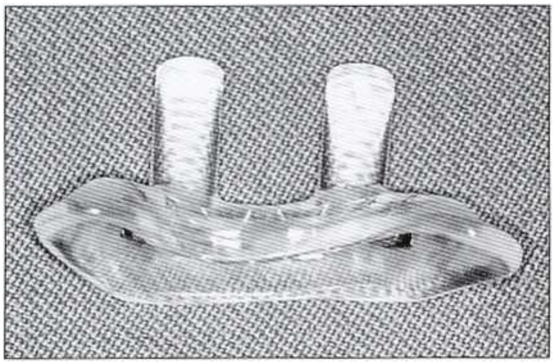


Fig 19-15 Acrylic-resin substructure showing the attached Plexiglass rods.

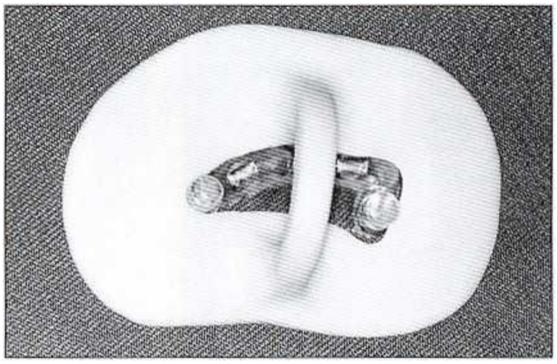


Fig 19-16 Custom tray in position on acrylic-resin substructure. Note the center portion of the tray has been cut to allow for visualization of the acrylic-resin substructure.

Skin Surface Impression and Master Cast Construction

The use of craniofacial osseointegrated implants allows for construction of a prosthesis that has enhanced appearance and improved functional performance. It also allows for minimizing contact of the prosthesis with the skin surface. To realize these benefits, a technique of recording the skin surface impression and constructing the master cast was developed. The technique provides for control of the anterior esthetic margin, a planned conchal margin, a designed internal aeration cavity under the prosthesis, and inclusion of a replica of the bar. The technique produces a master cast that allows processing replicate prostheses without returning the bar to the mold and thereby not depriving the patient of the use of the prosthesis during remaking of prostheses (Wolfaardt and Coss, 1996). The technique used is as follows:

1. On one of the acrylic-resin substructures, two shafts of 5.0-mm-diameter Plexiglass rod are added (Fig 19-15).
2. A custom tray is constructed in autopolymerizing acrylic resin that indexes onto the Plexiglass rods. The center of the custom tray is cut out to allow clear visualization of the resin substructure when seating the tray (Fig 19-16).
3. The planned position of the auricular prosthesis is marked on the skin surface. This position may be transferred from the planning templates.
4. Preauricular skin-surface depression is observed with the patient opening and closing the mandible, in protrusive and lateral excursions of the mandible, and in changes in head posture. The point of maximum depression of the skin surface is noted and the impression is recorded in this position. It may be necessary to use a mouth prop to maintain the mandible in the desired position.
5. The acrylic resin substructure is placed in position on the bar. The space between the substructure and the skin surface must be blocked out. The tip is cut off a disposable syringe (#412, Monojcct, St Louis, MO), and uncatalyzed silicone putty (Rapid-Soft, Coltcne, Altstatten, Switzerland) is loaded into the syringe. The silicone putty is syringed around the margin of the acrylic resin substructure and an instrument is used to remove the excess silicone putty (Fig 19-17).
6. The skin surface is coated with a thin layer of low-potency topical steroid ointment. This serves to aid in the release of the impression from the skin surface and reduces skin-surface irritation after recording the impression.

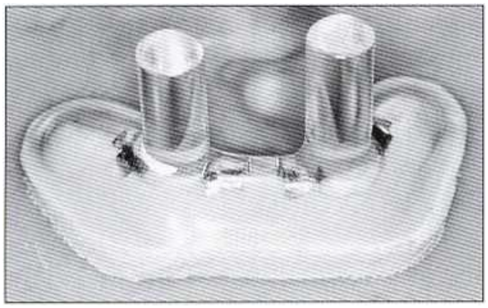


Fig 19-17 Space between the acrylic-resin substructure and the skin surface is blocked out with uncatalyzed silicone putty.

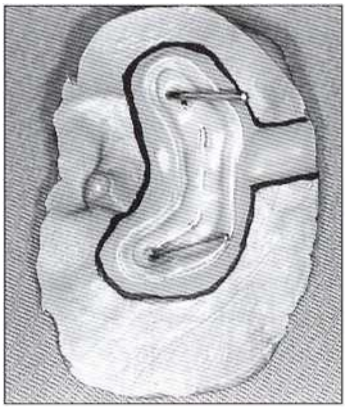


Fig 19-18 Recovered impression showing the aeration channel, the design of the internal aeration cavity, and the stainless steel duplicate of the bar.

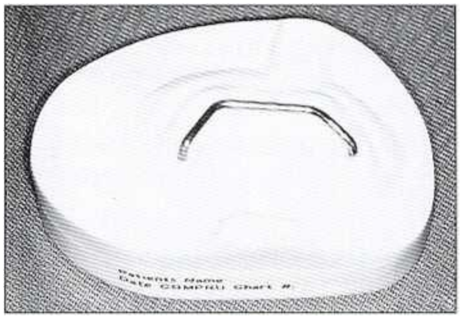


Fig 19-19 Master cast incorporating the duplicate of the bar, blockout for soft tissue spacing, the channel for the aeration cavity, and the anterior soft tissue recorded in a maximally depressed position for an esthetic margin.

7. The skin-surface impression is recorded in polyether impression materials. These malerials are used for their reliability in curing on skin surfaces. The surface of the custom tray is coated with adhesive (polyether adhesive, ESPE). Low-viscosity polyether impression material (Permadvne L, ESPE) is loaded into an impression syringe and any areas of concern arc syringed. Regular-viscosity polvether impression material (Impregum, ESPE) is loaded onto the tray. The custom tray is placed over the Plexiglas rods and seated into position. During seating of the tray, care must be taken to ensure that the relationship of the acrvlic-resin substructure and the bar has not been altered. The impression is recovered and the uncatalvzed silicone putty is cleaned off the impression surface.
8. The detailed anatomic template can be used to determine the design of the internal spacing of the prosthesis. The only areas where there should be skin contact are along the anterior esthetic margin and around the conchal margins.
9. Carbide rotary instruments are utilized to reduce the demarcated surface of the impression. A channel of entry for the aeration cavity under the prosthesis must be created posterior to the acrvlic-resin substructure (Fig 19-18).
10. A stainless steel wire (#075 hard 29, 1.90 mm, Malin’s Wire, Brookpark, OH) of diameter that matches the retentive bar is bent to replicate the bar and is introduced into the clips in the acrylic-resin substructure (Fig 19- 18). The impression is boxed and poured in a die stone.
11. The master cast produced by this technique incorporates the duplicate of the bar, the block out for creating the aeration cavity', the channel for the aeration cavity, and the anterior soft tissue recorded in a maximally depressed position for an esthetic margin (Fig 19-19).
12. The combination of the substructure and the master cast construction technique allows for replicate substructures and prostheses to be constructed conveniently, efficiently, and without depriving the patient of the use of the prosthesis while a new prosthesis is being constructed. The technique also allows incorporation of designed spacing for subprosthesis dermal aeration. The technique also allows for a well-adapted anterior esthetic margin that does not depend entirely upon arbitrary cast reduction.

Orbital and Midface Prosthesis Construction

The available implant components for orbital and midface prostheses do not always readily allow for separating out the steps of construction of the superstructure from the recording of the soft tissue surface. Where possible, the two-stage approach described for the auricular prosthesis is employed. Where a two-stage approach is not possible, in the orbit and midface, the impression of the abutments and soft tissue surfaces is recorded in one stage. The one-stage technique is described below.

Retention Selection

Little is known of the biomechanical behavior of osseoiintegrated implants in the orbit and midface. The orbit and midface can present complex geometrical challenges to retention design. Some have advocated very rigid superstructure designs while others have used relatively flexible configurations. The problem is made more complex in the orbit and midface by the fact that implants may be radially positioned with conflicting paths of insertion. Further complexity arises in large or combined defects where the superstructure crosses different biological environments or links areas of the craniofacial complex that have different mechanical behavior. An added challenge occurs if therapeutic radiation has been used, as this may further compromise the ability of the bone to respond to biomechanical load. Clearly, further biomechanical information on the use of craniofacial osseointegrated implants in this region of the facial skeleton is needed.

Understanding of the orbit and midface suggests the need for three implants not on the same straight line. Typically in the orbit, implants are placed into the lateral, infraorbital, and supraorbital rim. In a nasal prosthesis, implants are placed into the nasal floor and, if possible, the nasal bone area, although this area may require bone grafting. In extensive midfacial defects, while no specific guidelines exist, a conservative ingenuity is required to determine sites for implant placement.

Freestanding abutments with magnet retention or, alternatively, bar and clip retention are routinely employed in the orbit. In the orbit, given the problems of path of insertion, the most common approach is to use freestanding cantilevered abutments with magnet retention. Bar and clip systems can be used in a variety of situations.

Impression Recording

For purposes of explanation of the one-stage technique, the orbit with freestanding abutments and magnet retention will be used as an example.

1. In the case of orbital prostheses, it can be helpful to complete a diagnostic sculpting to determine space availability' for component positioning. Where space is a major concern, this should be done prior to surgery or prior to initiating prosthetic treatment.
2. The direction of emergence of the abutments is examined. It is desirable to have the retentive elements oriented to pull the prosthesis onto the skin surface. To achieve this and to have the retentive components in a position that is convenient to manipulate, cantilevered abutments may be selected. These abutments arc available in 30-, 60-, 90-, and 110-degree configurations (Console abutments, Entific Medical Systems) (Fig 19-20). A try-on set of Console abutments is available to allow for selecting the appropriate cantilever angle.
3. A magnet keeper is attached to the face of the Console abutment (Mini Magnacap, Technovent, Leeds, UK). The interface between the Console abutment and the Technovent keeper is sealed with a one-phase silicone sealant (Impla-Scal, Lifccore Biomedical, MN). This sealant keeps the magnet keeper front loosening due to torsional load during function.
4. The impression of the defect is recorded as a sectional silicone putty impression. The silicone putty (Rapid-Soft, Coltene) is layered in sections that are separated with petroleum jelly. Care must be taken to ensure that a path of withdrawal has been planned for each piece of putty. As each piece is laid down, its surface is indexed with the back of an instrument han-

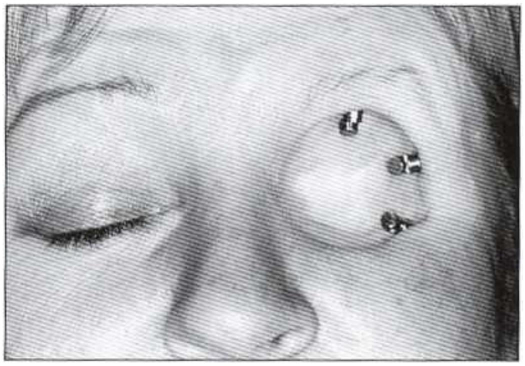


Fig 19-20 *(left)* View of an orbit with Console abutments connected and with magnet keepers connected to the Console abutments.

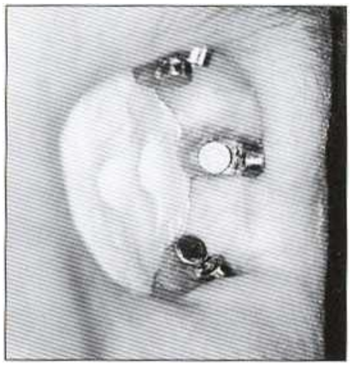


Fig 19-21 *(right)* View of the surface of the silicone putty impression of the orbit. Note indices in the silicone putty surface and wax blockout of Console abutments.

die so that the pieces of putty can be reassembled when recovered. The final layers of putty are used to block out the posterior of the Console abutments. Alternatively, this blockout can be achieved with utility wax (Fig 19-21).

5. Transfer magnets (Technovent) are connected to the keepers. The transfer magnets deliver a lower retentive force so that their position in the impression is not compromised during impression recovery.
6. The skin surface is sparingly lubricated with a low-potency topical steroid. This allows easier release of the impression and minimizes skin irritation. Low-viscosity polyether impression material (Permadyne L, ESPF.) is loaded into an impression syringe, and the area around the abutments and transfer magnets is syringed. Regular-viscosity polvether impression material (Impregum, ESPF.) is then syringed over the remainder of the area. The surface of the Impregum is syringed to form retentive loops for the acrylic-resin backing (Flexacryl Hard, Lang). The Flexacryl is added to cover the exposed surface of the Impregum impression.
7. The soft tissue impression housing the transfer magnets is recovered, as are the sections of the sectional impression. The silicone sections are cleaned to remove the petroleum jelly lubricant.

Master Cast Construction

1. The sections of the silicone impression and the polyether soft tissue impression are reassembled using cyanoacrylate adhesive.
2. The stainless-steel abutment replicas (DCB 175-0, Entific Medical Systems) are connected to laboratory magnet analogues (laboratory analogue magnacaps, Technovent). The path of insertion of the abutment replica-magnet keeper assembly to the transfer magnet in the impression is checked. Frequently, the path of insertion is obscured and will need to be created with a carbide rotary tool. Once the path of insertion is cleared, the abutment replica- magnet keeper assembly is connected to the transfer magnet in the impression (Fig 19-22).
3. The impression is boxed and poured in die stone.

Acrylic-Resin Substructure Construction

1. On the master cast, the path of insertion of the acrylic-resin substructure is decided. The area around the abutments is blocked out with wax, and the blocked-out wax is contoured using a surveyor for the desired path of insertion.
2. The magnets (Mini magnets, Technovent) are connected to the laboratory keepers on the cast.
3. Baseplate wax is used to form the borders of the designed acrylic-resin substructure. A stone overcast is constructed. The wax is boiled out and the surfaces of the cast and overcast are painted with separating medium and clear autopolymerizing acrylic resin (Splint Resin, Great Lakes). The acrylic resin is cured in a pressure pot.

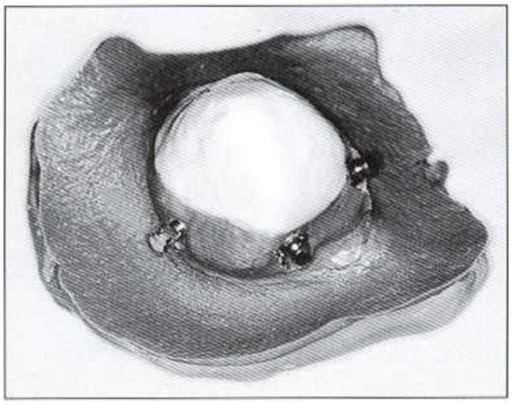


Fig 19-22 Impression of the orbital defect and the skin surface. Note the abutment replica- magnet keeper assembly connected to the transfer magnet in the impression.

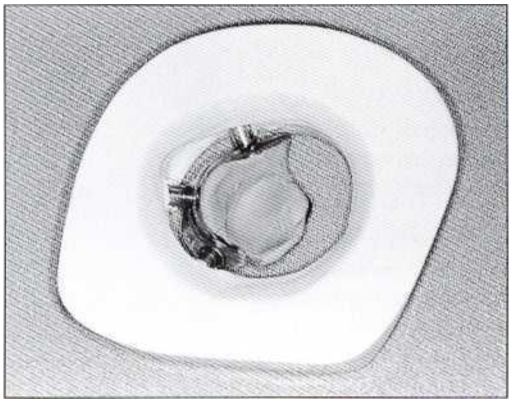


Fig 19-23 Posterior of the orbital cast showing removal of the internal portion of the cast to allow for development of an interior finishing line.

4. The acrylic-resin substructure is recovered, trimmed, and finished. Using the same procedure, additional acrylic-resin substructures may be constructed.
5. The fit of the acrylic-resin substructure is checked on the patient. A fit checking silicone (Fir Checker, GC, Tokyo, Japan) is used to confirm closure of the interface between the magnets and keepers.

Master Cast Modification

1. The internal and external finishing lines of the prosthesis are marked on the soft tissue surface of the cast. A diagnostic waxup, if available, can be of great assistance in determining the position of the finish lines.
2. Starting on the posterior surface of the cast, cast material is removed using a carbide rotary instrument. This is continued until all cast material on the inside of the internal finishing line is removed, which allows both an internal and external finishing line to be developed for the orbital prosthesis (Fig 19-23). The implication of this is that skin contact by the prosthesis is minimized to designed areas.

Fhe prosthodontist completes the final check of the superstructures and substructures. The prosthodontist also connects any screw-retained superstructures. At this point, the anaplastologist can begin the esthetic phases of prosthesis construction.

Maintenance

Space does not permit a full description of maintenance procedures but the following offers an outline of the basic procedures. The prosthodontist with an interest in this area should have a good background in wound care. Patients arc recalled 1 to 2 weeks after abutment connection for suture removal. Thereafter, the patient is seen at 3 months, 6 months, and annually thereafter, unless circumstances dictate otherwise. At these visits, pertinent parameters are recorded. During the early phases of healing, contemporary wound healing principles are applied. Once the wound is well healed, the patient is instructed on home care procedures. In the early experience of care of skin-penetrating abutments, aggressive hygiene methods such as the use of dental flosses and brushes were advocated. Given added experience and better understanding of the histology of the percutaneous interlace, these techniques could be traumatic to the interface and so a more delicate approach is now advocated.

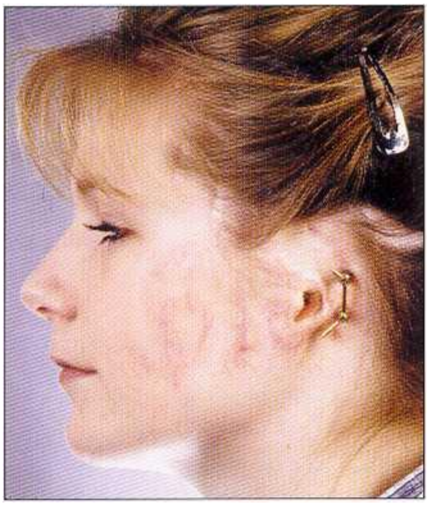


Fig 19-24a Patient who lost the left external ear in a motor vehicle accident. A bar connects two implants.

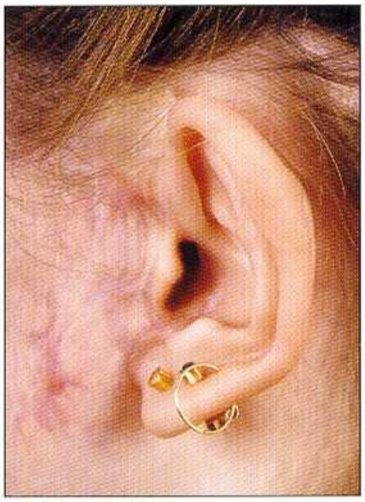


Fig 19-24b Close-up view of completed prosthesis.

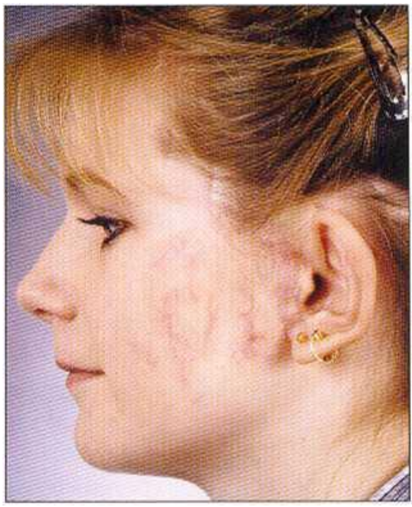


Fig 19-24c Completed auricular prosthesis.

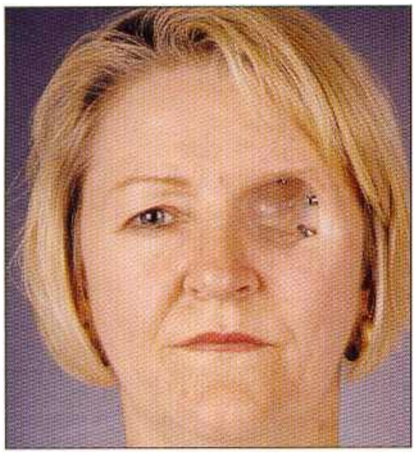


Fig 19-25a Patient who underwent a left orbital exenteration. Lonestanding Console abutments have been connected.

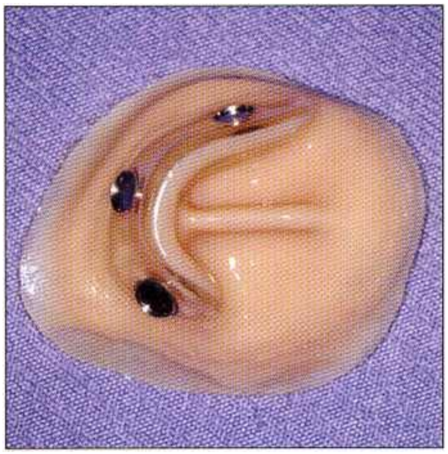


Fig 19-25b Fitting surface of the prosthesis housing the acrylic resin substructure and magnets.

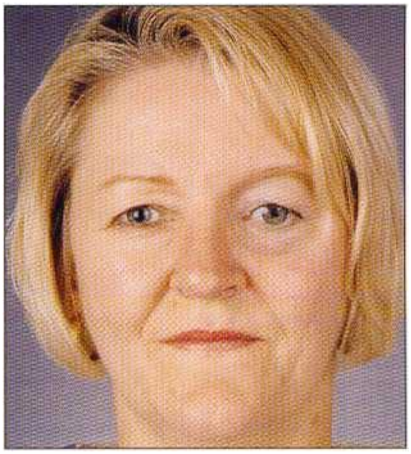


Fig 19-25c Completed orbital prosthesis.

Conclusion

Craniofacial osseointegrated implants provide facial defect patients with prosthetic treatment options that were previously unavailable. Facial defects may present in a great variety of ways and yet craniofacial osseointegration technology is remarkably adaptable to these differing situations (Figs 19-24 and 19-25). The techniques described above will require modification and adaptation to meet the host of challenges that facial defects may present.

References

Albrcktsson T, Branemark P-1, Jacobsson MD, Tjellstrom A. Present clinical applications of osseointegrated percutaneous implants. J Plast Reconstr Surg 1987;79:721.

De Valle V, Faulkner MG, Wolfaardt JF, Rangert B, Tan HK. Mechanical evaluation of craniofacial osseointegration retention systems. Int J Oral Maxillofac Implants 1995;10:491.

Tjellstrom A. Osseointegrated implants for replacement of absent or defective ears. Clin Plast Surg 1990;17:355.

Tjellstrom A, Linstrom J, Hallen O, Albrcktsson T, Branemark PI. Osseointegrated titanium implants in the temporal bone. Am J Otol I981;2:304.

Wilkes GFI, Wolfaardt JF. Auricular defect: Treatment options. In: Osseointegration in Craniofacial Reconstruction. Branemark P-I, Tolman D (eds). Chicago: Quintessence, 1998:141.

Wilkes GH, Wolfaardt JF. Craniofacial osseointegrated prosthetic reconstruction. Adv Plast Reconstr Surg 1998;! 5:51.

Wilkes GFI, Wolfaardt JF. Osseointegrated alloplastic versus autogenous ear reconstruction: Criteria for treatment selection. Plast Reconstr Surg 1994;93:967.

Wolfaardt JF, Coss P. An impression and cast construction technique for implant-retained auricular prostheses. J Prosthet Dent 1996;75:45.

Wolfaardt JF, Coss P, Levesque R. Craniofacial osseointegration: Technique of bar and acrylic resin substructure construction for auricular prostheses. J Prosthet Dent 1996;76:603.

Wolfaardt JF, Granstrom G, Friberg B, Jha N, Tjellstrom A. A retrospective study on effects of chemotherapy on osseointegration. J Fac Somato Prosthet 1996;2:99.

Wolfaardt JF, Tjellstrom A, Parcl S, Wilkes GH. International perspective on treatment outcomes. In: Osseointegration in Craniofacial Reconstruction. Branemark P-I, Tolman D (eds). Chicago: Quintessence, 1998:67.

Wolfaardt JF, Troppmann R, Wilkes GH, Coss P. Surgical templates for auricular reconstruction. J Fac Somato Prosthet 1996, Aug: 131.

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